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SUMMARY REPORT FOR USMA PLOWSHARES INITIATIVE

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13. ABSTRACT *(Maximum 200 words)*

The U.S. Army Simulation, Training and Instrumentation Command (STRICOM), through the Defense Modeling and Simulation Office (DMSO), was funded to transition military modeling and simulation (M&S) and training technology to civilian disaster management planning and decision making. Towards this end, STRICOM initiated the project PLOWSHARES program with the ultimate goal of leveraging existing military models and prototypes to determine applicable predictive model availability and conduct a proof-of-principal demonstration (POP-D) using a candidate M&S.

Three organizations were funded to execute this program under the direction of STRICOM. Because of it's experience in using military M&S for training and analysis, the Department of Systems Engineering (DSE), United States Military Academy (USMA), was funded to serve in the lead role for systems development, conduct training, develop after action analysis tools, and develop the terrain and scenario for the POP-D. The University of Central Florida's Institution for Simulation and Training (IST) was responsible to evaluate alternative M&S's for Phase II, serve as the systems coordinator, and document the results of the program. Lastly, the Training and Simulation Technology Consortium (TSTC) served as the commercial advocate and was responsible for developing county and state requirements. In addition, two contractors, nations Inc. and Resource Consultants Inc. (RCI), were hired mainly in computer programming roles.

The DSE role was further delineated into five separate areas to include: 1) terrain generation techniques/methodology, 2) scenario generation techniques/methodology, 3) prototype development 4) training and 5) after action analysis tools. A study of civilian and military faculty within the DSE was formed to conduct research in these areas. This report documents the DSE efforts to include: 1) provide a summary of all USMA activities for the PLOWSHARES project, 2) provide detailed documentation for developing terrain for the PLOWSHARES prototype model TERRA and 3) document the lessons learned in the event a Phase II is conducted.

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Acknowledgments

The Department of Systems Engineering (DSE), United States Military Academy (USMA), West Point, New York, is supporting the U.S. Army Simulation, Training, and Instrumentation Command (STRICOM) conversion of military technology for civilian emergency operations management training. The DSE provided support for this program, named PLOWSHARES, in five distinct areas: terrain generation, scenario management, development of a model prototype, training users, and after action analysis. All of these efforts culminated with a Proof of Principal-Demonstration (POP-D). The report summarizes these five efforts.

The work described herein was conducted by members of the staff and faculty in the DSE. Dr. John V. Farr served as senior investigator and was responsible for terrain generation. LTC Michael L. McGinnis and MAJ George F. Stone developed the concept for the scenario management software and were responsible for its implementation by a private contractor. Mr. Paul D. West directed the enhancements made to an existing military simulation to capture the major functions associated with emergency management operations and was also responsible for all training. MAJ Sue M. Romans and Cadet Gail Wilson conducted a study to develop measures of effectiveness (MOEs) for training conducted in support of emergency management operations. Mr. John A. Melendez used the results from this MOE study and developed a command and control data logger to capture data for after action analysis. Dr. Farr and Dr. Donald R. Barr developed the hurricane model ultimately used in the model and simulation. Dr. Farr and Mr. West wrote this report. The work was conducted under the general supervision of COL James L. Kays, PhD, Professor and Head, DSE, USMA.

Special thanks to Dr. Alan L. Zobrist and Mr. Tom J. Herbert, Rand, Santa Monica, California, for their assistance in developing the terrain database for the POP-D. Captian Mike Bass, Orange County Fire and Rescue, Orange County, Florida, helped design the command and control logger and provided a significant amount of expertise in the development of the POP-D scenario. Ms. Jean H. Burmester, STRICOM, Orlando, Florida, was the technical monitor for this work and the Program Manager for PLOWSHARES.

The work was conducted during the period 1 October 1994 through 31 September 1995. The methodology and result contained herein are not to be construed as official Department of the Army or Department of Defense position, policy, or decision. The methodology and results contained herein are solely the responsibility of the authors.

Executive Summary

The U.S. Army Simulation, Training, and Instrumentation Command (STRICOM), through the Defense Modeling and Simulation Office (DMSO), was funded to transition military modeling and simulation (M&S) and training technology to civilian disaster management planning and decision making. Towards this end, STRICOM initiated the project PLOWSHARES program with the ultimate goal of leveraging existing military models and prototypes to determine applicable predictive model availability and conduct a proof-of-principal demonstration (POP-D) using a candidate M&S.

Three organizations were funded to execute this program under the direction of STRICOM. Because of it's experience in using military M&S for training and analysis, the Department of Systems Engineering (DSE), United States Military Academy (USMA), was funded to serve in the lead role for systems development, conduct training, develop after action analysis tools, and develop the terrain and scenario for the POP-D. The University of Central Florida's Institution for Simulation and Training (IST) was responsible to evaluate alternative M&Ss for Phase II, serve as the systems coordinator, and document the results of the program. Lastly, the Training and Simulation Technology Consortium (TSTC) served as the commercial advocate and was responsible for developing county and state requirements. In addition, two contractors, Nations Inc. and Resource Consultants Inc. (RCI), were hired mainly in computer programming roles.

The DSE role was further delineated into five separate areas to include:

- terrain generation techniques/methodology,
- scenario generation techniques/methodology,
- prototype development,
- training, and
- after action analysis tools.

A study team of civilian and military faculty within the DSE was formed to conduct research in these study areas. This report documents the DSE efforts to include:

- provide a summary of all USMA activities for the PLOWSHARES project ,

- provide detailed documentation for developing terrain for the PLOWSHARES prototype model TERRA[1] , and
- document the lessons learned in the event a Phase II is conducted.

Other reports have or are being written by IST, RCI, and TSTC to serve as a user's guide for the TERRA model, details of the software changes made to Janus to create the TERRA model, training manual for TERRA, details of the command and control logger, user's guide for the scenario management model and the requirements for county and state level representation in an emergency operations training model.

[1] TERRA is the name of the Janus based model to be used for the proof-of-principal demonstration (POP-D). The name TERRA was derived based upon the female Roman god that personifies the earth and also for the acronym Training Emergency Rapid Response Allocation

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Summary Report for USMA PLOWSHARES Initiative

1. Introduction

1.1 Background

The U.S. Army Simulation, Training, and Instrumentation Command (STRICOM)[1], through the Defense Modeling and Simulation Office (DMSO), was funded to transition military modeling and simulation (M&S) and training technology to civilian disaster management planning and decision making. Towards this end, STRICOM initiated the project PLOWSHARES program with the ultimate goal of leveraging existing military models and prototypes to determine applicable predictive model availability and conduct a proof-of-principal demonstration (POP-D) using a candidate M&S.

Because of it's experience in using military M&S for training and analysis, the Department of Systems Engineering (DSE), United States Military Academy (USMA) was asked to develop a proposal with the long term goal of transitioning Department of Defense (DoD) technology to the private sector. Towards this end, DSE submitted a proposal (DSE, 1994) involving three concurrent initiatives centered around the development of a prototype computer simulation for the purpose of transferring existing military combat models and the supporting hardware technology to support civilian emergency and disaster relief training exercises. Specifically, the efforts by USMA faculty would have focused on modifying the Janus combat simulation currently being used to model low-level combat so that it can be used to model natural and man made disasters. In addition, two other concurrent efforts would have been undertaken to (1) define the broader simulation requirements for the STRICOM PLOWSHARES initiative, and (2) to survey other model and simulation environments that could be used for PLOWSHARES. These three concurrent efforts initially proposed are shown in Figure 1.1.

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[1] See Appendix A for a listing of all acronyms and abbreviations used in this report.

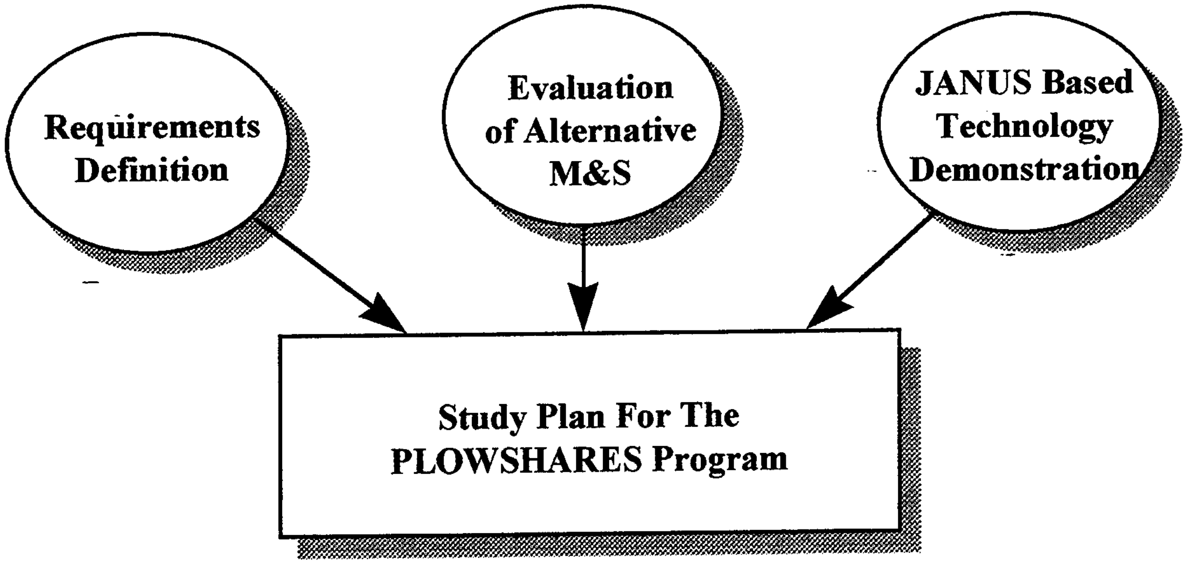

Figure 1.1 DSE strategy for PLOWSHARES program (DSE, 1994)

Because of the level of effort, available funding, and expertise that existed in other organizations, the final study plan called for three organizations to execute this program under the direction of STRICOM. The roles of the three agencies (Training and Simulation Technology Consortium or TSTC, the Institution for Simulation and Training or IST, and the USMA are shown in Figure 1.2.

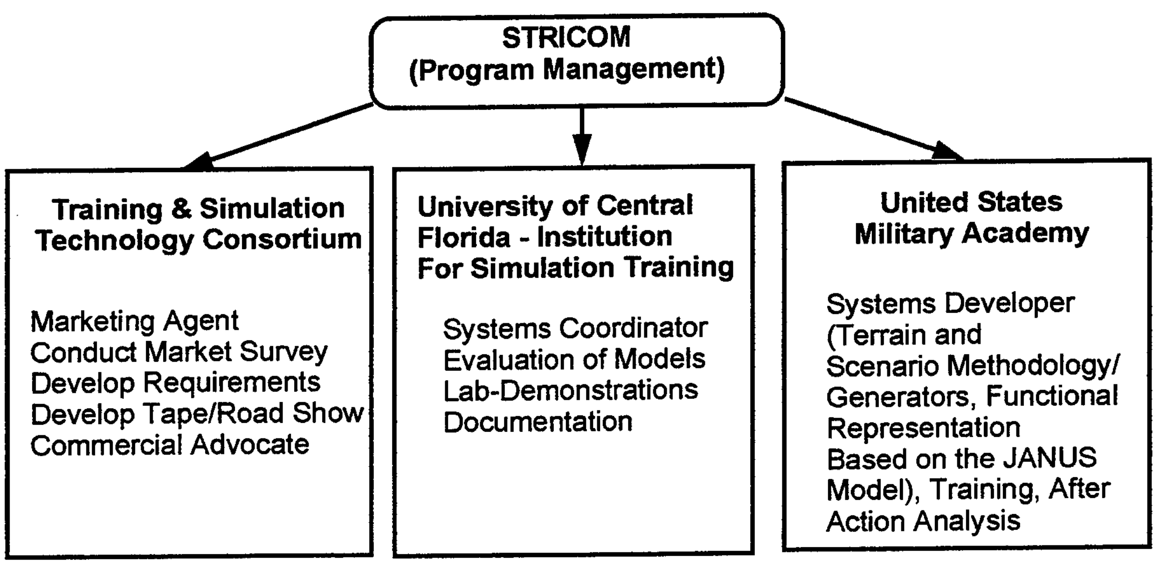

Figure 1.2 Majors roles for the PLOWSHARES program

In addition, two contractors, Nations Inc. and Resource Consultants Inc. (RCI), were hired mainly in computer programming roles.

The DSE role was further delineated into five separate areas as shown in Figure 1.3.

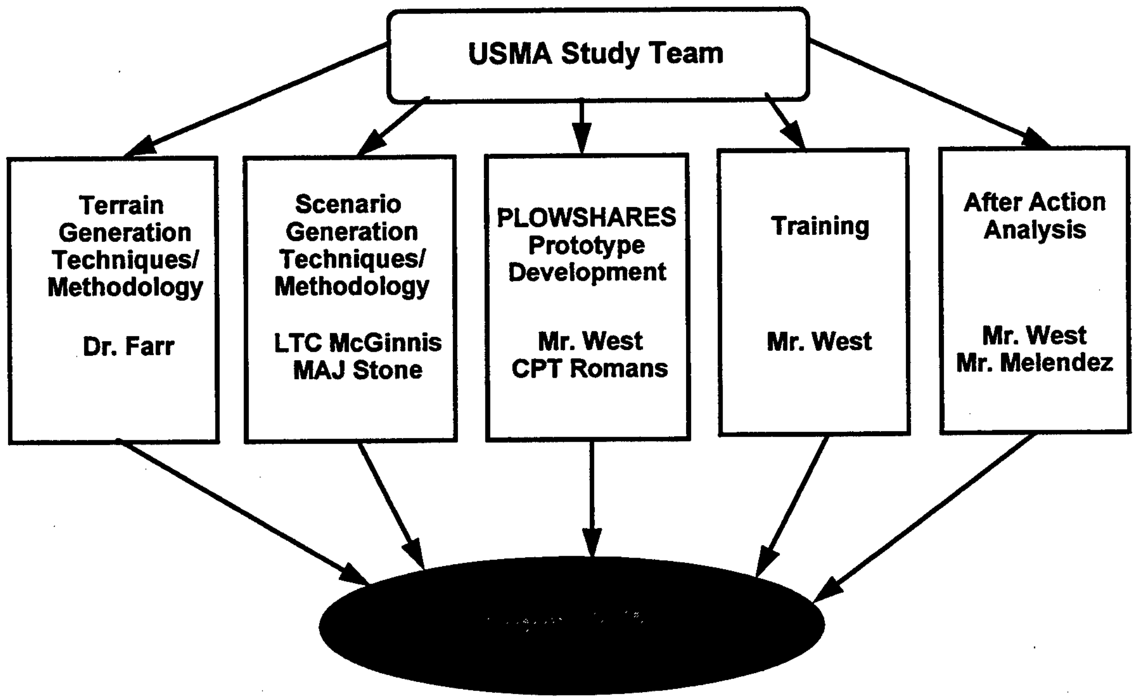

Figure 1.3 Areas of research and responsible individuals for USMA portion of the PLOWSHARES efforts

1.2 Purpose

This report serves several purposes to include:

- provide a summary of all USMA activities for the PLOWSHARES project to include those shown in Figure 3,
- provide detailed documentation for developing terrain for the PLOWSHARES prototype model TERRA[2], and
- document the lessons learned in the event a Phase II is conducted.

Other reports have or are being written by IST, RCI, and TSTC to serve as a user's guide for the TERRA model, details of the software changes made to Janus to create the TERRA model, training manual for TERRA, user's guide for the scenario management model and requirements for county level representation in an emergency operations training model.

1.3 Scope

Chapter 1 of this report contains background information about the PLOWSHARES project. Chapters 2 through 6 address the five research efforts shown in Figure 3. Specifically, Chapter 2 presents a detailed discussion of how to develop terrain for TERRA and details used in developing terrain for the POP-D. In addition, details of the terrain developed for Orange County, Florida, are presented. Chapter 3 discusses the System for Training Emergency Personnel (STEP) model. This training management tool was conceived by USMA and implemented by RCI. Chapter 4 presents the details behind the modification of the Janus combat simulation model used to create TERRA. Details about methodology along with a brief description of software changes and database manipulation are presented. Note that Nations, IST, and USMA all implemented changes, but USMA was responsible for management of all software change reports (SCRs). Chapter 5 presents lessons learned during training of users/operators. Chapter 6 addresses after action analysis efforts. Early in the program an effort was conducted to quantify measures of effectiveness (MOEs) for emergency operations training. Because of that effort, a command and control logger was written by DSE personnel. This chapter discusses the MOE research and the command and control logger. Chapter 7 contains the summary and conclusions.

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[2] TERRA is the name of the JANUS based model to be used for the proof-of-principal demonstration (POP-D). The name TERRA was derived based upon the female Roman god that personifies the earth and also for the acronym Training Emergency Rapid Response Allocation

This report contains four appendices. Appendix A contains a list of acronyms and abbreviations used in this report. Because TERRA was based upon a combat simulation model, some of the functions needed for an emergency operations training model are not represented in the final model. Appendix B contains a listing of the functions that should be portrayed in an emergency operations simulation training model for both man made and natural disasters and whether than can be portrayed in TERRA. Appendix C contains the mechanics of a hurricane model developed by the DSE. A version of this model, which was implemented by Nations Inc., provided the basis for the methodology of modeling hurricanes and tornadoes and subsequently damage the terrain. Lastly, Appendix D contains the training manual developed to conduct TERRA user/operator training. Also, described in that appendix are the mini scenarios used to exercise the emergency operations functions of the TERRA model.

2. Terrain Methodology

2.1 Introduction

Digital terrain data is a primary concern for an emergency management model such as TERRA. The DoD spends in excess of a billion dollars annually on terrain to support models and weapons systems. Many millions have been spent for terrain in support of Janus scenarios alone. Most municipalities will not have the resources to hire consultants to develop the terrain data for their locality. Therefore, some existing technology must be leveraged to satisfy this requirement.

One of the primary objectives early in the PLOWSHARES program was to develop an automated terrain capability. Thus, a survey of Janus users was conducted to identify an potential candidate geographic information systems (GIS) to serve as an automated terrain capability. The majority of users obtained the elevation data directly from the Training and Doctrine Command (TRADOC) Analysis Center (TRAC). Then using the Terrain Editor (TED) module of the Janus model (which was slightly modified for TERRA), roads, land use, barriers, etc., are manually inputted. At the time this survey was conducted (October 94), the only organization generating data (land use, roads, and elevation) from a variety of digital sources was the Rand Corporation. Their Cartographic Analysis and Geographic Information System (CAGIS) has been used extensively internally at Rand to develop Janus terrain databases from a wide variety of defense or commercially available digital terrain data. Other organizations such as the U.S. Army Engineer Waterways Experiment Station (WES) and the National Simulation Center (NSC) are developing terrain preprocessors that will convert Defense Mapping Agency (DMA) digital data to elevation data in a form that can be used by Janus. This would eliminate the need to obtain elevation data directly from TRAC. However, none are developing software that converts other than elevation data to a Janus readable format. Plans call for the NSC terrain generator to be able to import feature data from DMA products sometime during FY95.

For the TERRA[1] model, the only known potential candidate for a fully functional terrain preprocessor (produce TERRA data files containing elevations, road networks, and land use), given the time and economic constraints, was the CAGIS system (see Zobrist, et al., 1991). As shown in Figure 2.1, CAGIS can convert a wide variety of digital data into a form that can be used by a Janus derivative such as TERRA[2]. Unfortunately, CAGIS is a in-house tool used by Rand. Thus, a front end user interface is needed before the model can be used by people not familiar with CAGIS and GISs in general. Ultimately, CAGIS could be modified to support TERRA or a TERRA type model without a significant capital investment similar to that shown in Figure 2.2.

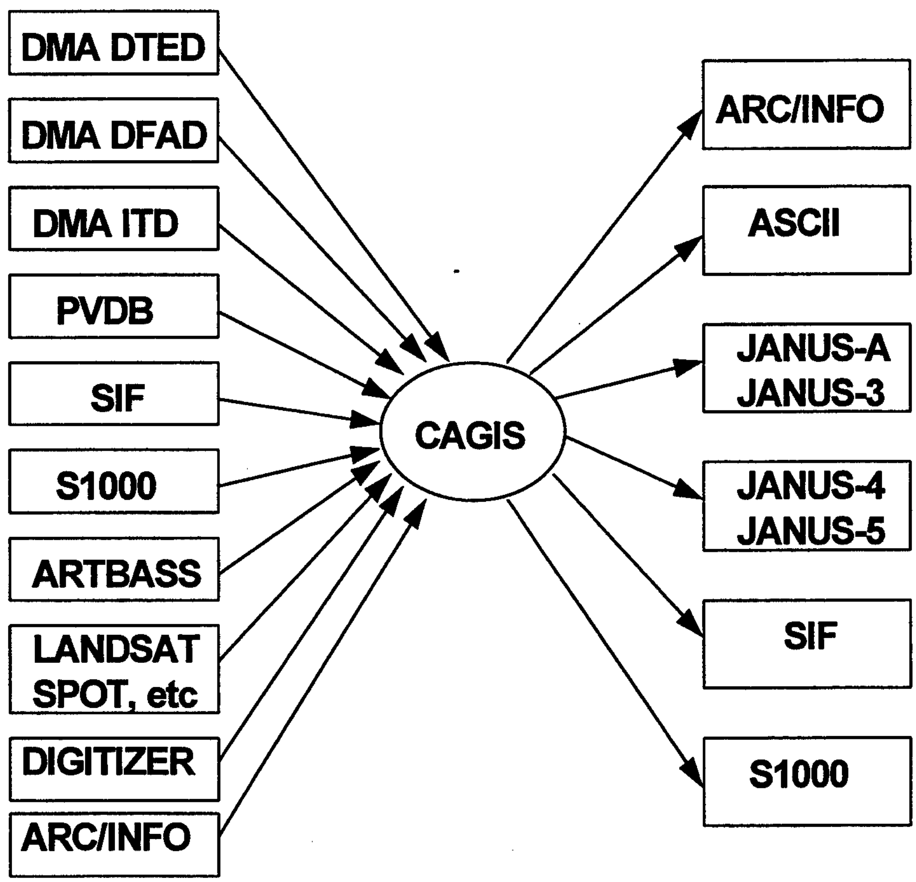

Figure 2.1 CAGIS format conversions

[1] Because TERRA is a JANUS derivative, the terrain files are nearly identical. The only exception is that terrain cells must be coded with burn rates and damage thresholds for the natural and man-made disasters. This information is contained in a separate file that must generated interactively using TED.

[2] Janus version 5.0 was used as the baseline for TERRA

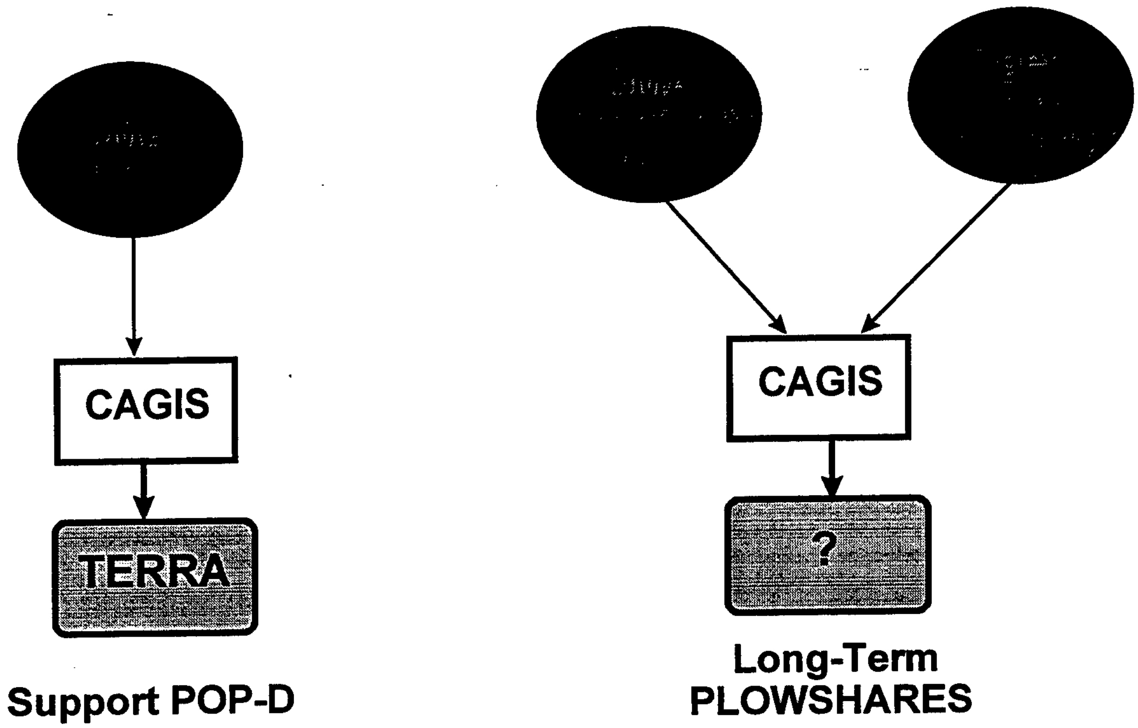

Figure 2.2 Functionality for modfied CAGIS to support PLOWSHARES

2.2 Terrain Generation for TERRA

Two terrain generation options exist for TERRA in its current form (Phase I prototype): 1) fund development of a CAGIS type preprocessor that will automatically produce elevation, road type and land use or 2) use methodology currently used for Janus (derive terrain elevation data from DMA products using existing preprocessors that are already developed and use TED for land features and road networks). Of the two, the latter is probably the more desirable in the near term for the following reasons:

- The issue of resolution has not been resolved for TERRA. For the POP-D, primary and some secondary roads were overlain onto a 60km x 60km terrain area. Smaller areas will require a greater density of roads. If road data from sources as TIGER are used, filters will be needed depending upon the feature resolution required. The combination of digital data from a variety of sources, filtering road densities and types as a function of scenario, etc., make

the development of a easy to use terrain preprocessor difficult and cost prohibitive.

- Since TERRA is written in FORTRAN, memory must be allocated at the start of program execution. Given that large terrain data files require several megabytes of memory, the arrays that store the terrain characteristics can be to small to capture the needed information. If the array size is exceeded, TED will corrupt the terrain database when edited. This happened when CAGIS was used to import TIGER road data in the early stages of developing the Orange County, Fl, database for the POP-D. When TED was used to edit out unwanted roads the entire database became corrupted. Until dynamic memory allocation can be incorporated into TERRA, the best way to develop a terrain database is to input roads using the digitizing capability of TED in some type of systematic way (primary, secondary in area of interest, other secondary roads, etc.) and test the terrain database to ensure it is working correctly at various stages of development.
- The time saved using a terrain preprocessor is insignificant compared to the cost of developing a fully functional preprocessor. By the time a county learns how to use a preprocessor, locates up-to-date digital products, and imports and edits the data, the time savings do not warrant the cost given that the primary customers for TERRA are presently counties. Also, once the terrain database is developed it will be reused for all major exercises or studies. Thus, this could be a one time process.
- A fully functional terrain preprocessor will only provide terrain elevation, land use, and roads. Major buildings, population densities, and burn rates will still have to be inputted via TED. The integration of TED and a fully functional terrain preprocessor is not financially viable. Thus, the user will still have to become familiar with TED.
- When the clients develop the database they have more control over the level of detail than if portions of the process were automated.
- Using TED to input roads and land use is not that time consuming. The total amount of time spent on developing the Orange County, Fl, TERRA terrain database was roughly two to three man-months.

In summary, if TERRA in its current form is fielded, the best procedure for developing terrain databases is to simply use one of the existing preprocessors that converts DMA data to digital elevation data, obtain up-to-date maps, and use the digitizing capabilities to input the road networks and land usage.

2.3 POP-D Terrain

In support of the POP-D, a 60km x 60km terrain database was generated the encompassed most of Orange and part of Seminole County, Fl. This terrain database is shown in Figure 2.3. The elevation information generated by CAGIS was used as an initial starting point for the database. Then using the digitizing capabilities of TED, major roads, lakes, parks, buildings, etc., were located using maps from a wide variety of sources.

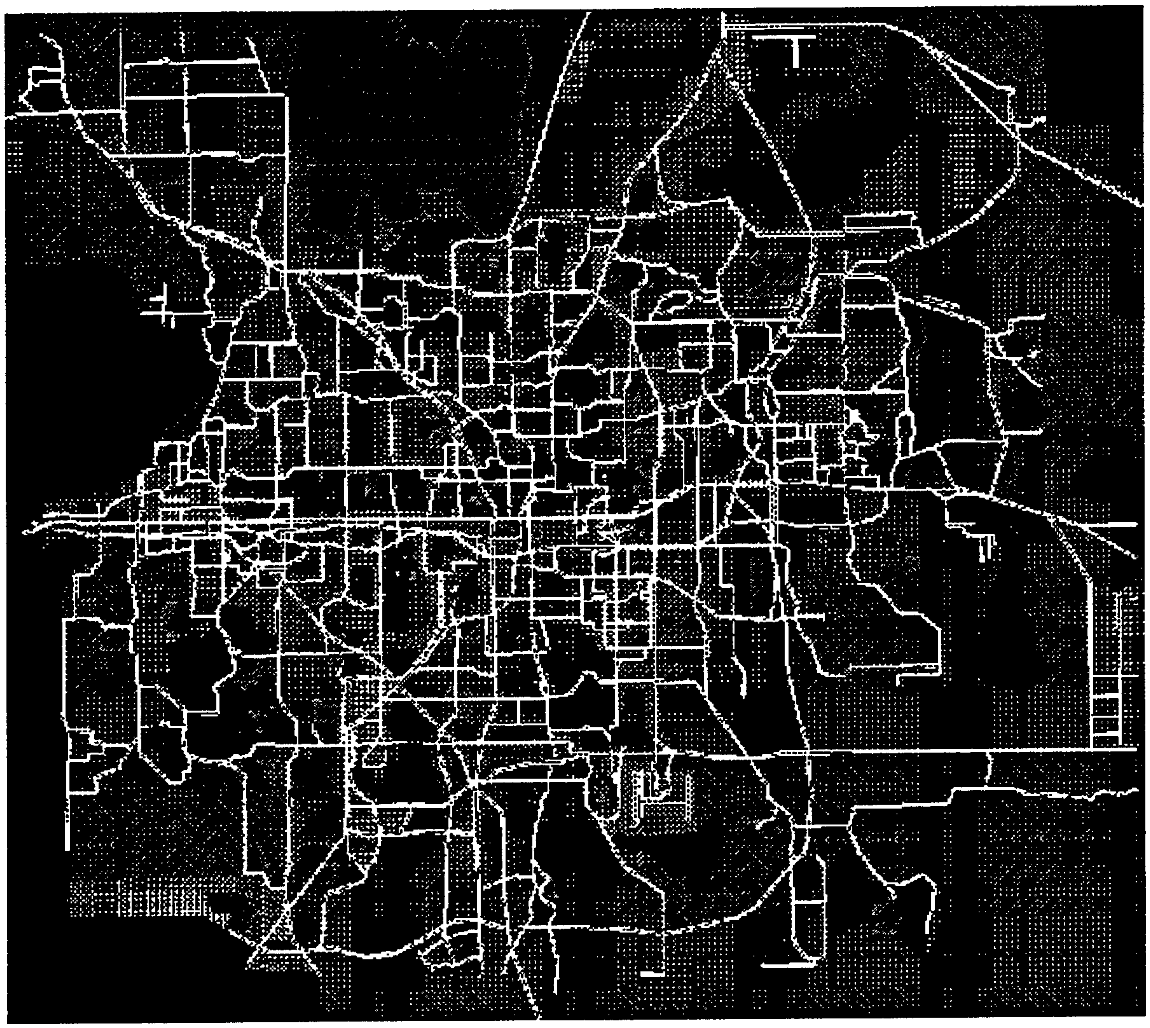

Figure 2.3 Orange County, Florida, TERRA terrain database

TED allows the user to code land usage, road types, and linear features. The terrain groups used to describe land usage are shown in Table 2.1. Note that only the urban and vegetation groups can be damaged by disasters. The parameters used to control burn rate, wind damage, and causalities are shown in Table 2.2. Note that these values were developed using one or a combination of the following procedures:

- Burn rates and damage thresholds were researched by Orange County Fire and Rescue (OCF&R) and input into the terrain database. The model was executed to determine whether these values were producing the desired functionality. Subject matter experts (SMEs) from OCF&R were used to evaluate whether the model was replicating what would happen during an actual disasters.
- Literature research was conducted on building damage thresholds by the development team from data as a function of wind loadings (see National Oceanic and Atmospheric Administration or NOAA, 1991). These values were synthesized and input by either IST, Nations, or USMA. The SMEs at OCF&R reviewed the results to ensure the proper functionality was being represented.

City Group

City Type	Description
1	Trailer Park
2	Residential Area - Older
3	Residential Area - Newer
4	1 Story Commercial Area
5	2 - 5 Story Commercial Area
6	5 - 10 Story Commercial Area - Older
7	5 - 10 Story Commercial Area - Newer

Road Group

Area Type	Description
1	4 Lane Major Roads
2	2 Lane Primary Roads
3	Airport Runways

Tree Group

Tree Type	Description
1	Undeveloped Open
2	Undeveloped Trees
3	Grass

String Group

String Type	Description
1	Railroad

Fence Group

Fence Type	Description
1	Not Used

Table 2.1 Categories used for roads and land features

River Group

River Type	Description
1	Flooded Areas

Area Group

Area Type	Description
1	Lakes
2	Paved Area
3	Park & Golf Courses

Table 2.1 continued

Burn Features and Population Density for Urban Area

Description	Fuel BTU/sq m	Burn Rate	Fire Spread Rate	Wind Damage Thresh	Population Density	Time To Burn (Min)
Trailer Parks	18	99.99	2.5	110	8	180
Res Old Com	21.6	90	2.25	125	12	240
Res New Com	27	90	1.5	135	36	300
1 Story Com	20.4	85	2	130	10	240
2-5 Story Com	25.5	85	2.25	175	20	300
5-10 Story Old	36	99.99	2.25	145	36	360
5-10 Story New	48	80	1.25	175	45	600

Burn and Wind Damage Features for Vegetation

Description	Fuel BTU/sq m	Burn Rate	Fire Spread Rate	Wind Damage Thresh
Undevelop Open	8.3	93	3	110
Trees	25.5	170	2.5	125
Grass	11.87	36.3	4	999
Parks & Golf	10	120	4.5	999

Table 2.2 Burn rate, damage thresholds, and population density for TERRA terrain cells

Note in Table 2.1 that the River Group contains a flooded area type. This descriptor was added in an effort to model flooded areas that occur during a hurricane. Areas that flood (using 100 year occurrence levels) were located on the Federal Emergency Management (FEMA), National Flood Insurance Program Maps and entered into the terrain database via TED as flooded areas. Note that two databases were constructed to support the POP-D: 1) one without flooded areas to be used in exercises without significant rainfall and 2) one with these flooded areas to represent actual conditions during a major hurricane.

In addition to the terrain descriptor groups described above, command and control (CAC) overlays were developed containing the information described in Table 2.3 were developed. These CAC overlays are simply vector map type overlays that can be used for planning an exercise or conveying information during an exercise.

Overlay Number	Description	Status
551	Firestations	Complete
552	Public Works	Complete
553	Shelters	Complete
554	Hospitals	Complete
555	Major Buildings	Complete
557	Sheriff Stations and Substations	Complete
560	Major Roads	Complete
561	Trailer Parks	Complete
563	Golf Courses and Parks	Complete
564	Bodies of Water	Complete
565	Ranges and Townships	Complete
566	Jurisdiction	Complete
567	Airports	Complete
568	Debris Clearance Routes	Complete
569	Wastewater Treatment Facilities	Complete
570	Water Treatment Facilities	Complete
571	Health and Community Services	Complete
572	Public Utilities	Complete
575	Combined Fire and Rescue Overlay	Complete
576	Combined Sheriff Overlay	Complete
577	Combined Public Works Overlay	Complete
578	Combined Public Utilities Overlay	Complete
579	Combined Health and Commercial Services Overlay	Complete

Table 2.3 CAC overlays for the Orlando database to be used for the POP-D

3. Training Manager

3.1 Introduction

The System for Training Emergency Personnel (STEP) model was originally conceived by USMA as a scenario generator as shown in Figure 3.1. However, developing an interface to take tasks, conditions, and standards data and convert that information into a form that could be used to generate TERRA scenarios was not achievable given the time and resource constraints. Thus, STEP evolved to more of a training management tool. The requirement to develop a functional representation of a training manager similar to the Combined Arms Tactical Trainer-Training Exercise Development System or CATT-TREDS has generated a lot of interest from all levels (county, state, and national). The interest is fueled by the need to manage training beyond using a M&S. Long term, a STEP product will be needed to successful manage and conduct training.

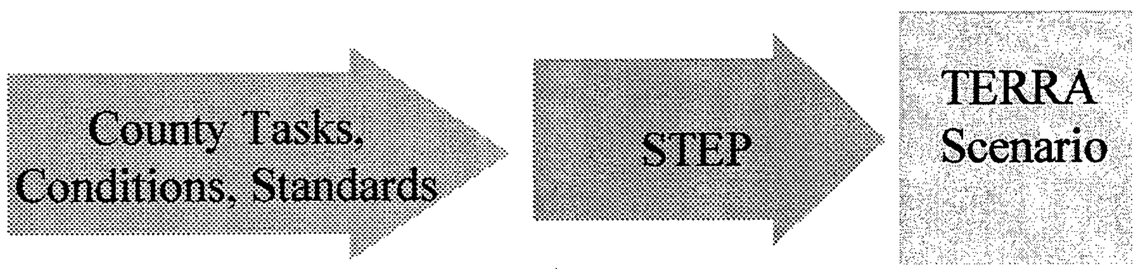

Figure 3.1 Initial STEP concept

RCI and TSTC in conjunction with Orange County, Fl (see Orange County, 1995), developed a set of tasks, conditions, and standards for emergency training. RCI has taken this document (see RCI, 1995) and using CATT-TREDS as a baseline inputted them into a database. These tasks, conditions, and standards can be used to plan training to conduct predetermined objectives. Note that RCI is developing a complete set of documentation for STEP.

3.2 Future Work

Ultimately, STEP needs to evolve to a scenario generator that accomplishes the functionality shown in Figure 3.2 and is described in more detail in Table 3.1. However, until the Phase II baseline[1] for TERRA is chosen, an interface that generates input files cannot be developed. Also, more requirements definition work is needed. STEP was modeled after CATT-TREDS because of the scope of this effort. The CATT-TREDS type tasks, conditions, and standards, user interface, etc., might not be the best approach for an emergency management exercises.

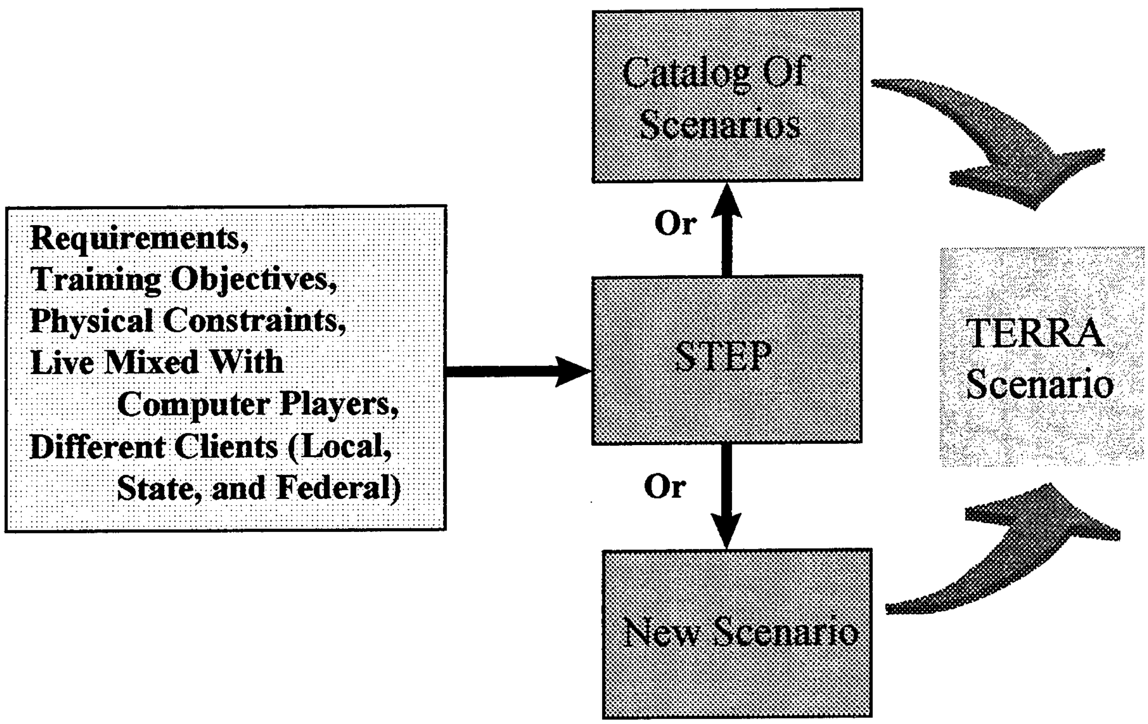

Figure 3.2 Proposed functionality for STEP

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[1] Janus was chosen as the initial baseline for TERRA because of the limited time frame of the project. Long term, the next generation of TERRA will probably be derived using a baseline model that supports distributed interactive systems protocol and is written in a modern object oriented language.

System Function	Description
Inputting	data to initialize the system (user interface)
Assessing	agency's training readiness for responding to civil emergency(s)
Selecting	1. training tasks based on agency's self-assessment 2. training events based upon a task list from 1 above a) combination of civil emergency events b) location (e.g., terrain, population density) c) degree of severity of the civil emergency
Prioritizing	training tasks based upon the training assessment
Identifying	type and quantity of resources available for the training exercise
Scheduling	the training events (event list)
Planning	for civil emergencies (planning tool)
Writing	plans, operation orders, and AARs
Communicating	plans and orders to agencies and key personnel
Processing	data and information—before, during, and after exercise (storing, retrieving, etc.)
Analyzing	data and information—before, during, and after exercise (statistical, risk, tradeoff, etc.)
Outputting	printing, viewing, and transferring 1. Data files (TERRA scenario files) 2. Information files (task list, event list, exercise schedule, resource requirements, AARs, and other reports)
Transporting	moving the STEP system to different training sites

Table 3.1 Function requirements for STEP

4. Model Development

4.1 Introduction

Model development was an important aspect of the total PLOWSHARES program. Initially, an "object to think with" model was proposed because the PLOWSHARES program was geared towards system requirements definition under Phase I. Lessons learned from this early phase would be used in subsequent efforts for the actual model development. However, as the program evolved, it became apparent that a working prototype that captured much of the functional representation as practical and used realistic physical models of an emergency training model was needed. The emergence of this requirement was based mainly of the need to provide a good working model for the POP-D, the need to exercise other tools such as STEP in a realistic environment, and the possibility that follow-on efforts would not be funded.

The roles and responsibilities for those involved in the actual development of the TERRA model are shown in Figure 4.1 USMA served as the focal point for assessing whether potential enhancements were do-able given the man power and time constraints of the project and could be handled with simple database manipulation or required code modification. In addition, because of USMAs Janus experience, they were responsible for developing much of the methodology that was ultimately implemented. Examples include

- the use of overlays to convey information that could not be explicitly modeled using TERRA,
- the ability damage terrain and assess causalities by inputting population density and representative building types into the terrain cells, and
- the methodology to damage buildings as a function of age and size for various hurricane levels using data structures similar to that already used by Janus.

Many of these ideas are presented herein.

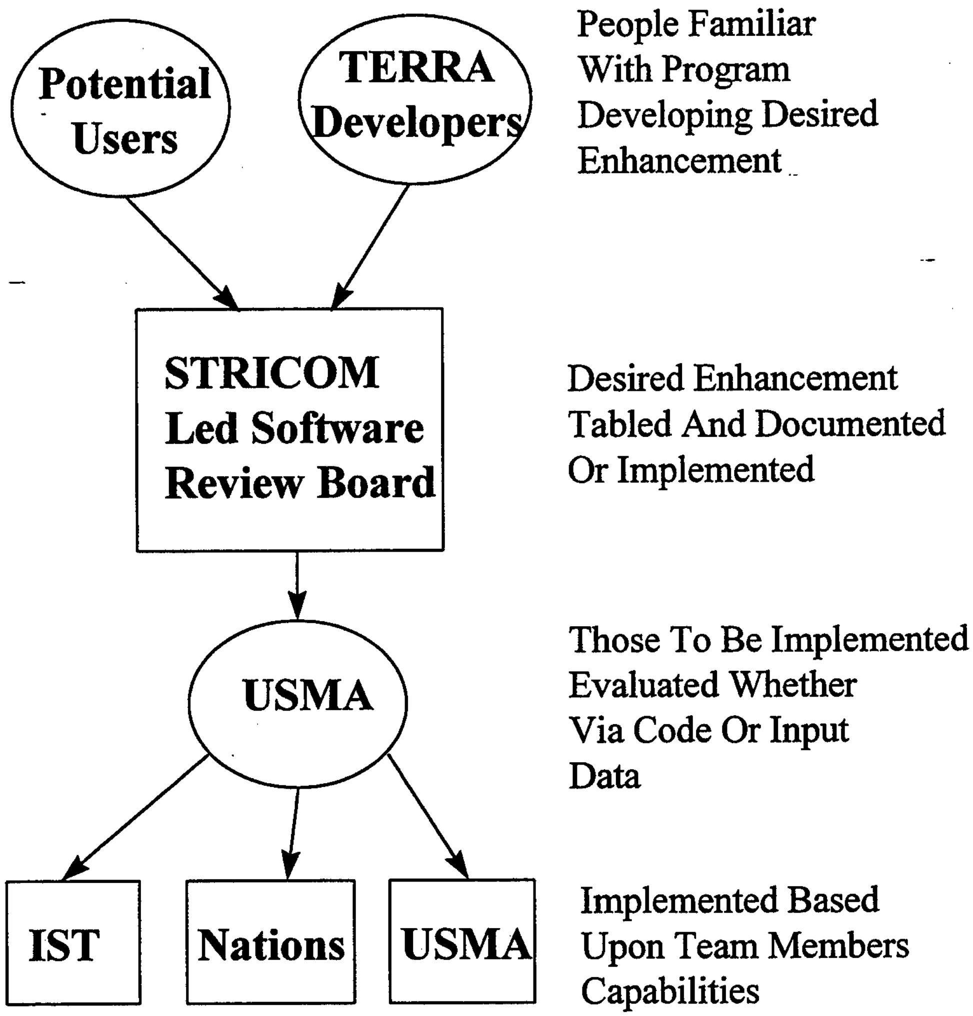

Figure 4.1 USMA role in the TERRA model development process

4.2 Software Changes

Listed in Table 4.1 are the software change reports (SCRs) generated to convert Janus to TERRA. Their status and the agency ultimately responsible for implementation is also contained in that table.

SCR	Purpose	Status	Agency Implemented
1	Rename "Combat Systems" to "Response Unit"	D	USMA
2	Implement hurricane and tornado models	D	Nations
2.1	Implement hurricane model	D	Nations
2.2	Implement tornado model	D	Nations
2.3	Implement terrain damage	D	Nations
2.4	JAAWS conversion for storms and terrain damage	D	Nations/IST
2.5	CONWOR conversion for storms and terrain damage	D	Nations/IST
3	Convert grids from UTM to Geodetic WGS 1984	D	IST
3.1	Provide functional UTM/Geo button to menu bars	D	IST
3.1.1	Add functional UTM/Geo button to Janus menu bar	D	IST
3.1.2	Add functional UTM/Geo button to JAAWS menu	D	IST
3.1.3	Add functional UTM/Geo button to CONWOR menu	D	IST
3.1.4	Add functional UTM/Geo button to CAC menu	D	IST
3.1.5	Add functional UTM/Geo button to TED menu	D	IST
3.2	Provide UTM/Geo option for information queries	D	IST
3.2.1	Return UTM/Geo coordinates in Janus queries	D	IST
3.2.2	Return UTM/Geo coordinates in TED queries	D	IST
3.2.3	Return UTM/Geo coordinates in creating terrain	T	NA
4	Change "Janus" name on interfaces	D	USMA
4.1	Remove "Janus" from JAAWS	D	USMA
5	Rename "Force" to "Response Unit"	D	USMA
5.1	Remove "Force" from hard copy printout of force file	D	USMA
6	Enable IF Shoot on the move	T	NA

Table 4.1 SCRs documenting changes to Janus to create TERRA

SCR	Purpose	Status	Agency Implemented
7	Fire model	D	NATIONS
7.1	Fire events	D	NATIONS
7.2	Fire fighting	D	NATIONS
8	Display C&C information on EOC terminal	T	NA
8.1	Display "reported" and "confirmed" icons	T	NA
9	Display difference menu bars for Blue, Red, EOC	T	NA
9.1	Customize standard Blue menu bar	T	NA
9.2	Customize standard Red menu bar	T	NA
9.3	Customize EOC menu bar	T	NA
10	Provide after-action analysis tool	D	USMA
10.1	Postprocess / transfer files to PC for analysis	D	USMA
10.2	Unix conversion routine	T	NA
10.3	PC piece of conversion routine	T	NA
11	Provide an icon for minimized windows	D	USMA
12	Provide a TERRA user login name	T	NA
13	Rename "abatis" to "fallen tree"	D	USMA
14	Rename Killed and Suppressed to Destroyed and Damaged	T	NA
15	Provide on-screen resource log (PC logger)	D	USMA
16	Replace "X" and "D" letters in map view	T	NA
17	Show availability of resource by color	T	NA
18	Associate icon color with resources	T	NA
19	Change background color to white	T	NA

Table 4.1 continued

SCR	Purpose	Status	Agency Implemented
20	Attach terrain feature data to info button	D	NATIONS
21	Provide key reference data in CACs	D	NATIONS
22	Rename Janus Analyst Workstation (JAAWS) to TERRA Replay	D	USMA
23	Demilitarize TERRA setup screens	D	USMA
24	Develop an evacuation methodology for TERRA	D	IST
25	Demilitarize Force (Response Unit) Editor	D	USMA
26	Rename program executables to reflect TERRA naming conventions	D	USMA
27	Not used		NA
28	Document cleanup of Janus source tree	D	IST
28.1	Modification of "make" com files to reflect terra names.	D	IST
28.2	Deletion of global file links and unused files, and creation of "make" utility scripts and associated files.	D	IST
28.3	Replaced shell scripts for new version	D	IST

D = Done, T = Tabled

Table 4.1 continued

Note that the SCR listing can be misleading with regards to level of effort. For example, SCRs 3, 7, and 10 require a significant amount of systems design and programming. The actual code modifications performed for these SCRs will be documented by IST.

Note that some of the TERRA code development is not reflected in the SCR listing. For example, a lot of effort was expended by USMA to modify the makefile used to compile Janus and develop a error free baseline model. Some of the major problems encountered in this process were

- No documentation describing the compilation process nor the compilers needed,
- Received incomplete trees or wrong version from contractor on at least three occasions,
- Make files provided would not support the UNIX version, and
- Numerous compilation errors because global files were developed to maintain VAX and UNIX versions.

4.3 TERRA Functionality Needed For Phase II

One of the main products needed for Phase II is the functionality requirements needed for an emergency training simulation. A listing of the desired functionality along with whether TERRA can portray that functionality explicitly or with external message traffic is contained in Appendix B. The desired functions are separated into natural and man-made disasters. Also, they represent the functions associated with a county level simulation. A regional of national training model would have a different set of desired functions.

4.4 Hurricane Modeling

Appendix C contains details of the hurricane model and methodology used to assess damage developed by USMA as a function of building age and type. A similar methodology was ultimately implemented by Nations Inc., and is described by Woods, et. al., (1995). The methodology developed

- approximates the first principal physics associated with a hurricane,
- produces algorithms that can easily be implemented and are at the same level of resolution as other algorithms in Janus,
- uses existing methodology for categorizing buildings, and
- quantifies the effects of hurricanes on certain types of buildings.

4.5 Terrain Modifications for Assessing Casualties and Damage

Populating terrain in TERRA was based on these concepts:

- Buildings and people must be represented and must be vulnerable to disasters.
- Individual buildings are not necessary and would require an unmanageable amount of detail.
- Population densities must be flexible so that time-of-day factors can be reflected.
- Accurate attrition rates are necessary to quantify effects of varied response efforts.

The solution was to "zone" the terrain with zoning and census data available from Orange County. The TED was modified to encode terrain cells with its enhanced type; which includes structure type, potential fuel (in btus), population density per terrain cell. Menus were added to the Performance Data Editor for customizing disaster characteristics as shown in Table 4.2.

HURRICANE CHARACTERISTICS								
Scale Num	Wind Spd (km/hr)	Ground Spd (km/hr)	Dist At Which Max Wind Spd Is Half (km/hr)	Eye Radius (km)	Prob Of Causing Fire (%)	Prob Of Causing Tornado (%)	Prob Of Causing Casualty (%)	Percent Max Wind Speed For Eye (%)
1	145.00	25.00	48.00	16.00		.00002	.00001	.2000
2	160.00	30.00	48.00	14.00		.00003	.00001	.2000
3	200.00	45.00	55.00	11.00		.00003	.00001	.2000
4	225.00	50.00	64.00	9.00		.00005	.00002	.2000
5	260.00	60.00	80.00	7.00		.00006	.00002	.2000

TORNADO TYPE DEFINITIONS						
Scale	Category	Wind Spd (km/hr)	Ground Spd (km/hr)	Life Span (min)	Prob Of Causing Fire (%)	Prob Of Causing Casualty (%)
0	Gale	51.00	28.00	5.50		.0001
1	Moderate	95.00	30.00	5.25		.0001
2	Significant	128.00	35.00	7.80		.0001
3	Severe	200.00	55.00	9.00		.0002
4	Devastating	256.00	61.00	9.50		.0005
5	Incredible	278.00	43.00	10.50		.0005
6	Inconceivable	356.00	51.00	11.00		.0030

FIRE FIGHTER SYSTEM CHARACTERISTICS			
Fire Fighter Type	Effective Distance (m)	Extinguish Rates (gal/s)	Number Of Hoses
1	100	100	5
.	.	.	.
.	.	.	.

Table 4.2 Menus added to the Performance Data Editor for customizing disaster classifications

Data input in Tables 4.2 combine with the terrain types in Table 2.1 to produce damage and casualties depending upon the events produced by the simulation. If left untreated, fires spread to adjacent terrain cells (or burn out if all fuel is expended) and casualties increase as a function of time. Fires and tornadoes can be initiated automatically by greater events, such as hurricanes, or can be launched by the exercise manager from a "Red" screen. This enables trainers to better control the flow of the simulation.

5. TERRA Training

Initially, training was not an area of responsibility for USMA (DSE, 1994). However, as the program evolved this became a necessary and major requirement. The USMA was responsible for several types of training to include

- Janus familiarization for IST and RCI,
- TERRA systems administration training for Orange County, and
- county user training for TERRA.

All of these efforts required a substantial amount of preparation. In support of the Janus familiarization effort, USMA developed a self paced training manual. This manual evolved into what was ultimately used by USMA for the county user training and is contained in Appendix D. Systems administration training was conducted informally using one-on-one type training.

Some important lessons were learned during the conduct of the training to include:

- a substantial amount of time must be invested by the user to effectively interact with the model during an exercise,
- personnel who were not very computer literate could be taught to execute the various tasks needed to perform during an exercise,
- training was more effective is each player concentrated on the specific area (i.e., public works clearing road debris), and
- because of the complexity of the model, the users must practice routinely to perform effectively.

Note that the IST is writing a TERRA training manual based upon the USMA developed manual contained in Appendix D.

6. After Action Analysis

6.1 Background

An after action analysis tool was not part of the original USMA study plan. As the program evolved, the need for an AAR tool became apparent to analyze results for assessing training effectiveness support for the POP-D and to develop an "object to think with prototype" for Phase II. Quantifying measures of effectiveness (MOE) and developing a prototype for evaluation during the POP-D based upon OCF&R requirements required an extensive effort. Fortunately, the research produced some innovative techniques for capturing the command and control aspects of a computer based training exercise.

Initially, this effort concentrated on developing a Janus type post-processor. Work accomplished on this effort included:

- developing the shell script code to capture and partition TERRA output into a form that can be inputted into the post processor and
- develop an initial menu driven AAR tool using Janus type output (events and time).

However, it became apparent that the type of information needed for meaningful AARs was mainly command and control issues such as how long did it take to respond to a certain event, what priorities were placed on events, etc. Capturing these communications events so they can be quantified and form the basis of measures of effectiveness (MOEs) drove the creation of the TERRA Command and Control Logger (TCCL).

6.2 The Communication Environment

Command, control, and communications within the Orange County Emergency Management system rely on agency Emergency Operations Centers (EOCs) interacting with a centralized County EOC. Agency managers talk directly or through intermediaries representing each of the Emergency Management Functions (ESFs). The general flow is from the policy makers through the ESFs to the agency EOCs for action. Other events are reported by deployed units or are called in by civilians. Routine responses may reach adjacent and higher agency managers as information only. Actions normally reach the ESF level only if they require intra-agency coordination or resources beyond those the agency can provide.

Agency EOCs such as Fire/Rescue and Sheriff's Office maintain radio contact with their deployed units and use the telephone system as their primary

link to County policy makers and ESFs. Hand-written logs are photocopied and distributed to managers and affected ESFs.

6.3 The Logger Concept

The TCCL (Logger) goal was to capture essential information being relayed through the normal process, catalog it in a way that can be analyzed by computer, and provide output to assist in the AAR process. Several approaches were tried -- from faithfully replicating existing paper forms to adding event "traps" to TERRA software. Existing paper forms proved too subjective and vague for simple analysis due to their reliance on narrative. The latter approach yet may prove useful if used in conjunction with a tool like the Logger, but was too programming-intensive for the time available.

The adopted solution was a database utility that would provide each agency a series of user-friendly point-and-click input forms. Agency input would feed a master database via local area network (LAN). Agencies would be able communicate with the County EOC or other agencies. The Country EOC could monitor all traffic, but each agency would "see" only those messages addressed to it. Enhancements were added so that each agency could track its deployed units by ID number, current location, destination, and status. The County EOC could get an identical snapshot for all county resources.

6.4 Logger Software and Hardware

Microsoft Access provided the database engine for the Logger. The application was written using the Access Developer's Toolkit and Visual Basic. Windows for Workgroups running on PCs was selected as the operating system interface because of it ability to easily share drives over the network.

The PC also was selected as the platform due to the initial plan to run TERRA on PCs using an X-windows emulator. This plan changed in early August 1995 when it was decided that displaying TERRA on X-terminals would present a better graphical visualization for the POP-D. The PCs now would serve as Logger platforms only. The addition of another computer at each agency work site added a requirement for a second computer operator. This was prudent since the load required of the operators proved too great for a single person. Long term the concept of having the simulation and software to capture command, control, and communications aspects of emergency operations training is desirable.

Communication control was achieved by setting read permissions on a shared network database. The database physically resided on the County EOC's machine. Each agency EOC was numbered according to its ESF category (e.g., Fire/Rescue = EOC 4). The County EOC was given EOC number zero, and read/write permissions for all other EOCs. Logger software on each machine periodically sampled the master database for new messages. Operators had the additional capability to sample on demand by clicking an "Update" button.

6.5 User Interface

6.5.1 Summary Screen

The initial user screen displays summaries of messages addressed to that EOC. Figure 6.1 shows the summary for the County EOC.

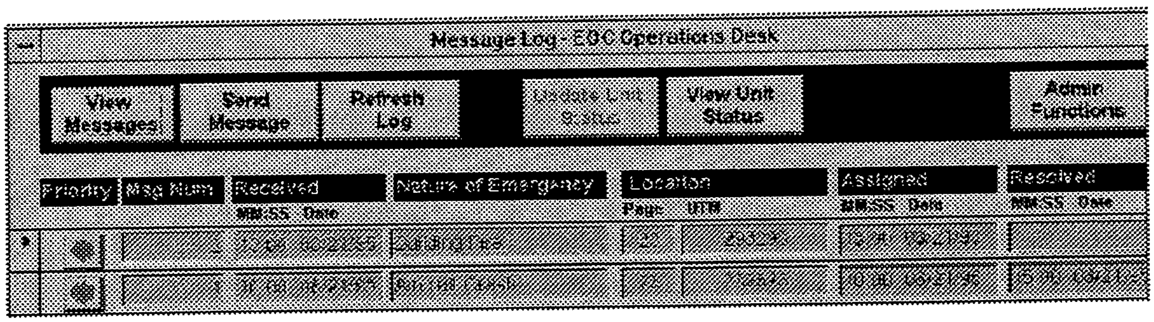

Figure 6.1 The TCCL message summary

Each summary lists messages by priority and is color-coded for quick identification, as shown in Table 6.1.

Color	Priority
Red	Urgent
Magenta	Normal Response
Amber	Low Priority
White	No Response Required
Green	Message Resolved
Blue	Further Action Required

Table 6.1 Priority codes

Other entries highlight key fields in the original message. The page location refers to the page number in the OCF&R map book carried by in all Fire/Rescue vehicles. This system, along with Universal Transverse Mercator (UTM) grid locations, was adopted for all agencies for the POP-D with the understanding that County plans include equipping all vehicles with satellite-linked global positioning systems (GPS) in the foreseeable future.

The original message can be reviewed by selecting row, then by either clicking on View Messages or double-clicking the area between the color code and the marginal arrow.

6.5.2 Send Message Screen

Selecting Send Message displays the screen shown in Figure 6.2.

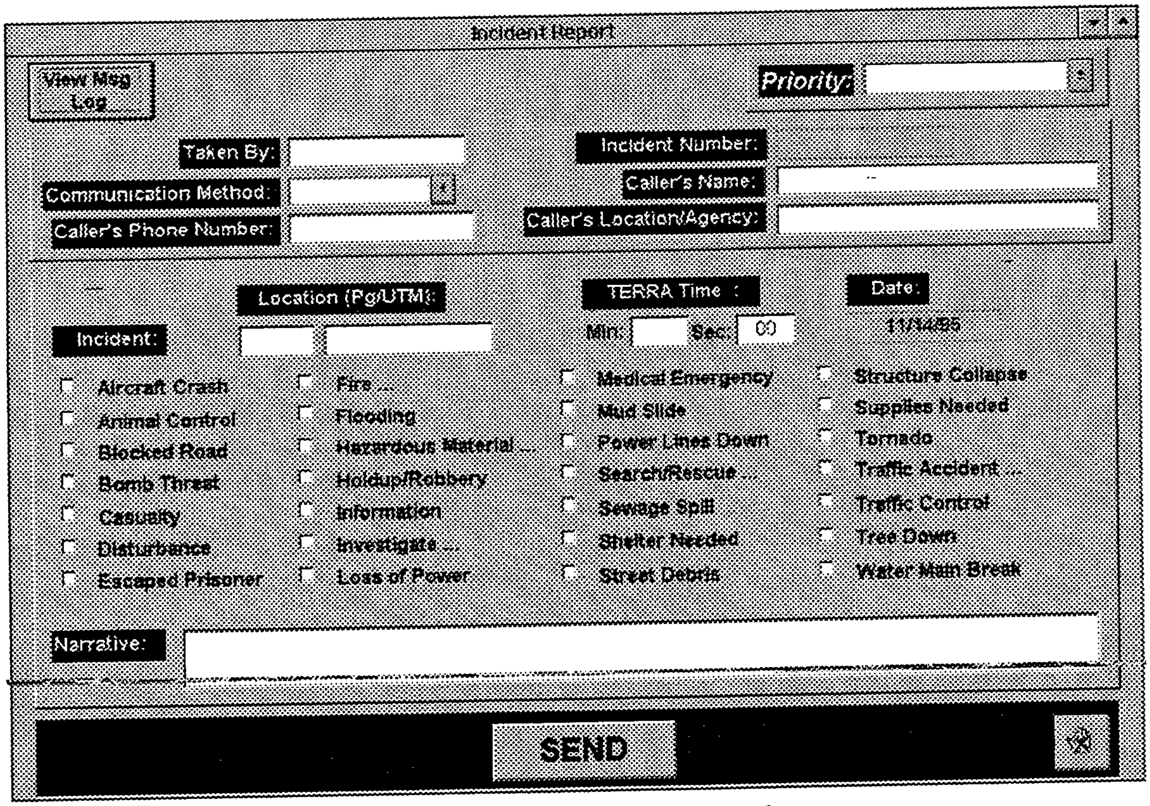

Figure 6.2 Incident reporting form

The color code appears in the **Priority** column. Colors will change as the priority of response changes. An event will change from Red - Urgent to Green - Resolved when units are dispatched. If the response is insufficient for any reason, a follow-on message can re-escalate the priority and require a new response. This way, the most pressing resourcing needs are at the top of the list.

If more than one agency is assigned to an event the color code will not turn to Green until both agencies have acted, allowing County managers and sister agencies to ensure that their partners in an emergency have picked up the call. The color code will turn Blue when all assigned agencies have reacted.

Many of the fields of optional, allowing operators to skip a high level of detail if time is critical. Other fields, however, are essential for tracking the report and are required before the report can be sent. These fields are Priority, Location (page and UTM), and TERRA Time, the game time displayed in TERRA (seconds are optional). Possible events were compiled from discussions with emergency management officials and from mission-essential tasks (see Orange County , 1995).

Events followed by an ellipse indicate available subcategories, as shown in Figure 6.3. Once selected, the sub-event replaces the original event (Figure 6.4).

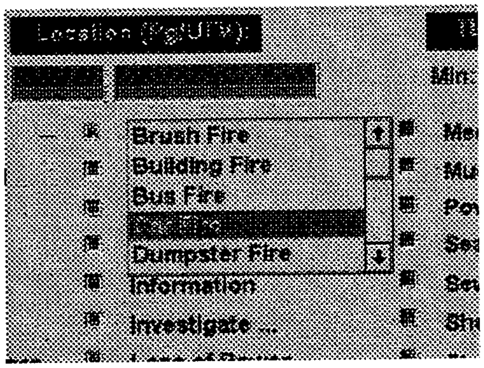

Figure 6.3 Incident submenu

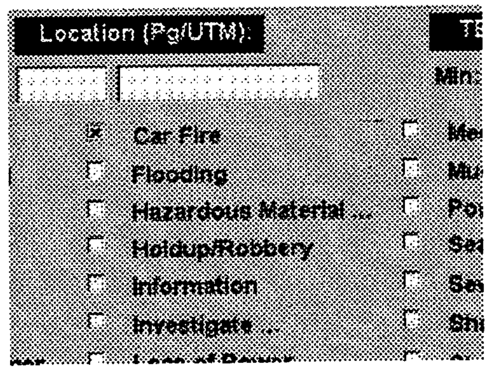

Figure 6.4 Replacement event

6.5.3 EOC Assignment

The Logger has the flexibility of operating at several levels of command, allowing decentralized exercises and bottoms-up.

Once an incident has been reported, managers assign it to one or more agencies for action or information. A common use of the information feature is to keep the Public Affairs Office informed. Figure 6.5 shows the Assignment screen.

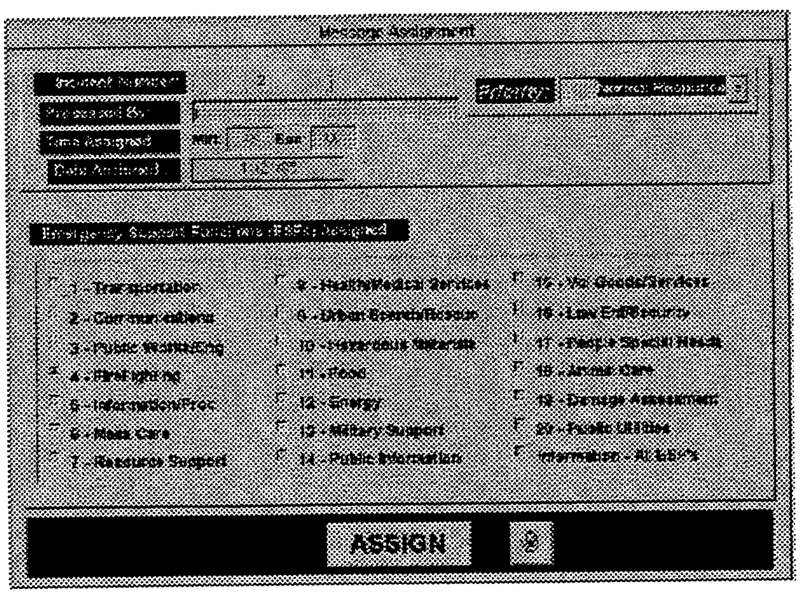

Figure 6.5 Message assignment screen

6.5.4 Incident Response

The Assignment tool allows selected agencies to view and act on incidents. An **Incident Response** screen (Figure 6.6) allows agency managers to assign vehicles, perform cross-agency coordination, and forward information copies of activities. As with the **Incident Report** form, space is provided for an optional narrative.

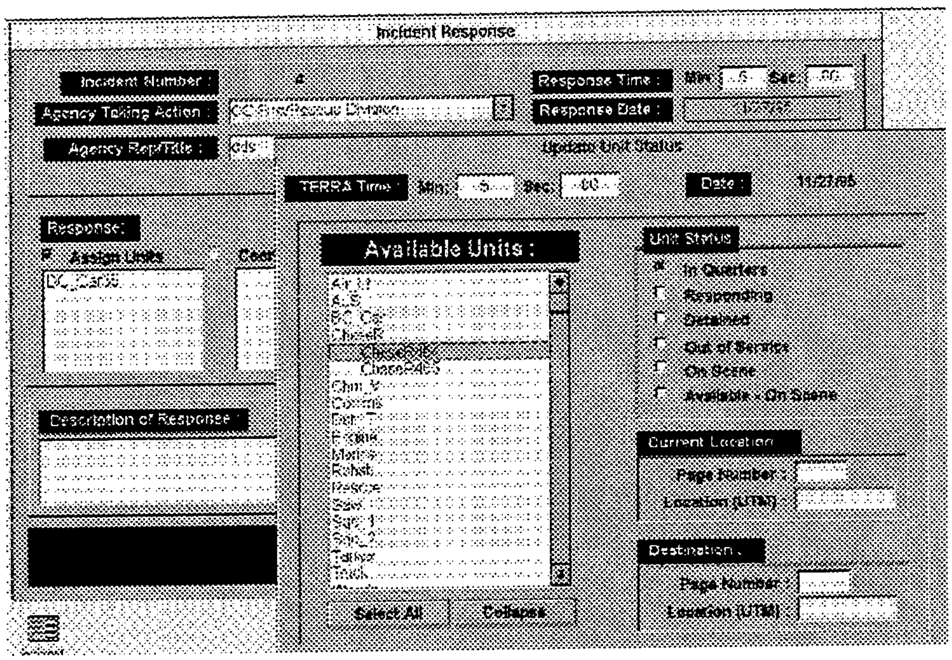

Figure 6.6 Incident response and unit status

6.5.5 Unit Tracking

Managers track units through the **View Unit Status** utility. This displays the Unit Status Report window (Figure 6.7) and provides a snapshot of all deployed units.

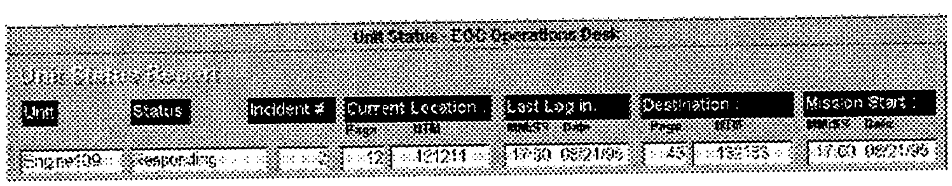

Figure 6.7 Unit status report

6.6 Future Work

Ease of use and database update speed topped the recommendations for enhancements following the POP-D. Future work should center on these areas and in directly linking TERRA and the Logger, enabling real-time reports and updates via software.

7. Summary and Conclusions

The DSE role in support of project PLOWSHARES was delineated into five separate areas to include:

- terrain generation techniques/methodology,
- scenario generation techniques/methodology,
- prototype development,
- training, and
- after action analysis tools.

This report documents the efforts conducted by DSE in these five areas.

The initial goal of the PLOWSHARES program was to produce an "object to think with simulation" as groundwork for Phase II. The goals of follow-on efforts was to produce a M&S that was suitable for a wide range of commercial users both inside and outside of the government for training emergency management operations. Also, the follow-on M&S must be flexible enough to be used at multiple echelons (county, state, region, and national). This initial effort produced some excellent work to feed any subsequent efforts to include:

- developing a methodology for addressing levels of resolution problems,
- develop a methodology for damaging terrain from natural disasters,
- develop a methodology for capturing and measuring command and control aspects of emergency management training,
- assessing the applicability of articulating user requirements in the task, conditions, and standards format used by the military,
- identifying user needs through interaction with SMEs at all levels,
- development of a prototype training manager,
- identifying sources of terrain data and the types needed to accurately model a county level exercise, and
- captured lessons learned in training county personal using a complicated M&S.

The end result of the PLOWSHARES program was a M&S that OCF&R could use for continued training exercises. Also, for the county level, TERRA could be used by other counties for training during emergency operations.

Feedback from the POP-D showed that meaningful training could be conducted using a TERRA type model. In addition to training for emergency

operations, this type of model can be used for a wide variety of analytical studies to include:

- siting county assets to respond to many types of emergencies,
- evaluate the worth of new equipment,
- study tactics for sheriffs operations (similar to military operations),
- look at high resolution vignettes of actual disasters, and
- look at alternate ways of conducting command and control during emergency operations.

In summary, the PLOWSHARES program produced numerous expected and unexpected benefits. Also, this type of program (i.e., mainly requirements definition coupled with prototyping and a POP-D), was needed because of the lack of research in using M&S for training emergency operations. The PLOWSHARES program was an excellent example of the conversion of defense technology to a worthwhile civilian sector application.

8. References

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Zobrist, A. L., Marcelino, L.J., and Daniels, G.S., "RAND'S Cartographic Analysis and Geographic Information System (RAND-CAGIS): A Guide to System Use" Report No. N-3172-RC, Rand Corporation, 1991.

Appendix A: Acronyms and Abbreviations

Abbreviation	Description
AAR	After Action Review
CAC	Command and Control
CAGIS	Cartographic Analysis Geographic Information System
CATT-TREDS	Combined Arms Tactical Trainer - Training Exercise Development System
DA	Department of the Army
DMSO	Defense Modeling and Simulation Office
DoD	Department of Defense
DMA	Defense Mapping Agency
DSE	Department of Systems Engineering
FEMA	Federal Emergency Management Agency
FORTRAN	Formulation Transformation
GIS	Geographic Information System
IST	Institution for Simulation and Training
M&S	Models and Simulations
MOE	Measure of Effectiveness
NOAA	National Oceanic and Atmospheric Administration
OCF&R	Orange County Fire and Rescue
POP-D	Proof of Principal Demonstration
RCI	Resource Consultants Incorporated
SCR	Software Change Report
SME	Subject Matter Expert
STEP	System for Training Emergency Personnel
STRICOM	Simulation, Training, and Instrumentation Command
TED	Training Editor
TERRA	Training Emergency Rapid Response Allocation
TRAC	TRADOC Analysis Command
TRADOC	Training and Doctrine Command
TSTC	Training and Simulation Technology Consortium
USMA	United States Military Academy
WES	U.S. Army Engineer Waterways Experiment Station

Appendix B: TERRA Functionality

Man-Made Disasters

Disaster	Events	TERRA	Unable	External
Civil Disturbance	1.1 Damage major buildings	x		
& Terrorists	1.2 Damage residential and commercial areas	x(7)		
	1.3 Dispatch teams	x		
	1.4 Put out fires	x		
	1.5 Model rioter - police interaction	x		
	1.6 Evacuation of residents		x	
	1.7 Damage affect traffic flow		x	
	1.8 Rubble affects teams	x		
	1.9 Effects of tactics and weapons on rioters	x		
	1.10 Command and control of assets	x		
	1.11 Communicate with other agencies			x
	1.12 Traffic control		x	
	1.13 Clear rubble	x		
Enviro Pollution	2.1 Casualities on civilians	x(7)		
& Haz Accidents	2.2 Dispatch teams	x		
& Indus Accidents	2.3 Put out fires	x		
& Nuc Disasters	2.4 Evacuation of residents		x	
& Oil Spills	2.5 Command and control of assets	x		
& Pipe Break	2.6 Communicate with other agencies			x
	2.7 Traffic control		x	
	2.8 Spread Pollutant		x	
	2.9 Model initial chemical spill	x		
Building Collapse	3.1 Damage major buildings	x		
	3.2 Dispatch teams	x		
	3.3 Put out fires	x(7)		
	3.4 Evacuation of residents		x	
	3.5 Damage affect traffic flow		x	
	3.6 Command and control of assets	x		
	3.7 Communicate with other agencies			x
	3.8 Traffic control		x	
	3.9 Clear rubble	x		
High Accidents	4.1 Dispatch teams	x		
	4.2 Put out fires	x		
	4.4 Damage affect traffic flow		x	
	4.5 Command and control of assets	x		
	4.6 Communicate with other agencies			x
	4.7 Traffic control		x	

Natural Disasters

Disaster	Events	TERRA	Unable	External
Flooding	1.1 Identify disaster areas	x		
	1.2 Evacuate disaster areas	x		
	1.3 Modify terrain as a function of time and rain		x	
	1.4 Dispatch teams	x		
	1.5 Develop alternative routes	x		
	1.6 Different terrain databases for various rain	x		
	1.7 Communicate with other agenices			x
	1.8 Loss of potable water		x	
	1.9 Loss of sewer		x	
Hurricanes	2.1 Damage major buildings	x		
	2.2 Damage residential and commercial areas	x		
	2.3 Dispatch teams	x		
	2.4 Put out fires	x		
	2.5 Damage by hurricane spanned tornadoes	x		
	2.6 Evacuation of residents		x	
	2.7 Damage affect traffic flow		x	
	2.8 Rubble affects teams	x		
	2.9 Modeling flooding dynamically		x	
	2.10 Command and control of assets	x		
	2.11 Communicate with other agencies			x
	2.12 Traffic control		x	
	2.13 Different terrain databases for various rain	x		
	2.14 Loss of power		x	
	2.15 Spawn fires	x		
	2.16 Clear rubble	x		
	2.17 Loss of sewer		x	
	2.18 Loss of potable water		x	
Thunder Storms	3.1 Damage major buildings	x		
	3.2 Damage residential and commercial areas	x(7)		
	3.3 Dispatch teams	x		
	3.4 Damage by storm spanned tornadoes	x		
	3.5 Evacuation of residents		x	
	3.6 Damage affects teams	x		
	3.7 Rubble and trees affects traffic	x		
	3.8 Modeling flooding dynamically		x	
	3.9 Command and control of assets	x		
	3.10 Communicate with other agencies			x
	3.11 Traffic control		x	
	3.12 Different terrain databases for various rain	x		
	3.13 Loss of Power		x	

Sink Holes	4.1 Damage major buildings	x		
	4.2 Damage residential and commercial areas		x	
	4.3 Dispatch teams	x		
	4.4 Evacuation of residents		x	
	4.5 Damage affects teams		x	
	4.6 Command and control of assets	x		
	4.7 Communicate with other agencies			x
	4.8 Traffic control		x	
Tornadoes	5.1 Damage major buildings	x		
	5.2 Damage residential and commercial areas	x(7)		
	5.3 Dispatch teams	x		
	5.4 Evacuation of residents		x	
	5.5 Damage affect traffic flow		x	
	5.6 Rubble and trees affects traffic	x		
	5.7 Command and control of assets	x		
	5.8 Communicate with other agencies			x
	5.9 Traffic control		x	
	5.10 Loss of Power		x	

Appendix C: Hurricane Methodology For PLOWSHARES

Introduction

In order to properly capture hurricane effects, a methodology must be developed that:

- approximates the first principal physics associated with a hurricane,
- produces algorithms that can easily be implemented in to JANUS,
- use existing methodology for categorizing buildings, and
- quantifies the effects of hurricanes on certain types of buildings.

One of the limitations on any enhancement for PLOWSHARES is that the functional representation remain balanced. In other words, the model does not need to be slanted (i.e., very high resolution when other functional representations are captured with a low level representation) with a certain analytical capability. If certain functions are grossly captured, it does not make sense to develop a hurricane model that captures all of the physics associated with the phenomenon.

A stochastic building damage model is proposed based upon the maximum wind speed experienced by a building as a storm passes. The wind speed is modeled in terms of the vector sum of the storm velocity and the wind velocity relative to the storm center.

Hurricane Model

Assume the amount of damages to a given structure from a hurricane is proportional to the drag where

$$D \alpha (V^2 . \rho) \tag{1}$$

where

D = drag
V = air velocity
ρ = air density

If air density is assumed to be constant for our simplification, the drag is proportional to the square of the air velocity, V^2. The air velocity can then be used as input for damage threshold curves (see Modeling Building Types section).

To generate V^2 at a given time and location, a total velocity vector $\vec{V}_t$ can be determined by adding the hurricane generated wind velocity vector $\vec{V}_h$ to the relative ground velocity of the hurricane, $\vec{V}_r$, as shown below

$$\vec{V}_t = \vec{V}_h + \vec{V}_r \tag{2}$$

Thus, to determine V^2 at a given time and location (x,y), $\vec{V}_t$ is determined from Equation 2 and its squared length computed,

$$\vec{V}_t \bullet \vec{V}_t = \| \vec{V}_t \|^2 \tag{3}$$

Note that $\vec{V}_r$ is determined from the scenario derived input as shown in Figure 1. To use the bivariate normal hurricane velocity model, assume the storm center is at (Cx, Cy) and we want to compute $\vec{V}_h$ at any position (x,y). $\vec{V}_h$ is simply the vector orthogonal from the line (Cx,Cy) to (x,y) having length

$$\| \vec{V}_h \| = k\, e^{-\frac{1}{2}(x - Cx, y-Cy)\Sigma\,(X-Cx, y-Cy)'} \tag{4}$$

Note that k is the difference between the maximum wind speed oriented in the counter-clockwise direction and relative ground speed, $\| \vec{V}_r \|$

This model allows flexibility to model elliptical shapes through choice of parameters in the matrixΣ. For simplicity, a simple circular model will be used as shown in Figure 1, taking Σ to be the form

$$\begin{pmatrix} \alpha & 0 \\ 0 & \alpha \end{pmatrix}$$

The computations required in implementing this model are modest.

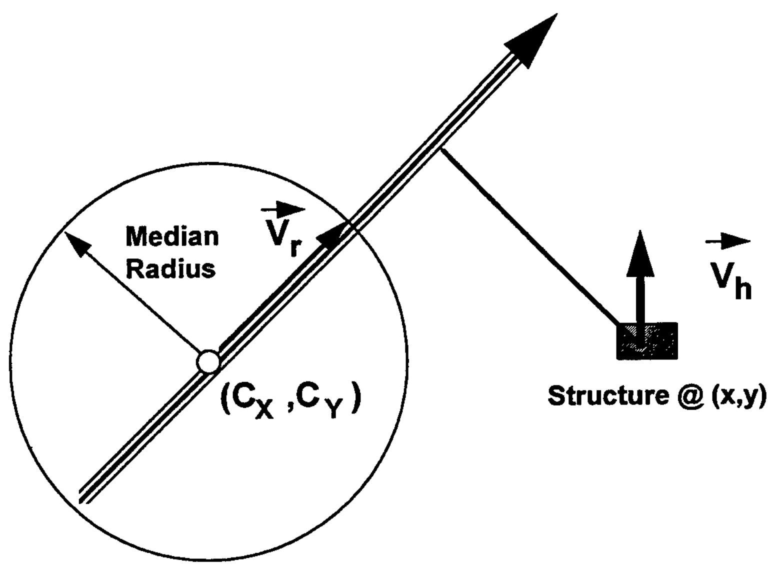


Figure 1. Geometry of simple hurricane model

Example 1. Suppose a storm with a maximum wind speed of 100 MPH is headed northeast at a ground speed of 18 MPH. Suppose a mobile home is situated 25 miles due east of the storm center at a given time as shown in the following figure. Determine the total wind speed at the mobile home.

Figure 2. Example 1 geometry

Solution: Note that $(x - Cx, y - Cy) = (25,0)$, since the structure is 25 miles due east of the storm center. If the storm is heading in a northeasterly direction , then the storm relative ground velocity vector is (12.73, 12.73). Also, shown in Figure 2 is the median storm radius. The median radius or M_r is the distance from the storm center to the point where the wind velocity is one-half of the maximum amount.

The length of the hurricane generated wind velocity vector can be expressed using Equation 4 for the bivariate normal distribution.

[redacted]

where α is determined from the boundary conditions in the following manner: At the center the hurricane generated speed is expressed as

[redacted]

The speed is 50 MPH at the median radius M_r of 75 miles. Thus,

[redacted]

But this is 1/2 of the maximum hurricane speed, k/2. Therefore the above equation is equal to k/2 or

[redacted]

or

[redacted]

or $$\alpha \approx 2.465E\text{-}4$$

To determine k, the design hurricane has maximum total wind speeds of 100 MPH. If the ground speed is 18 MPH then the maximum hurricane generated speed must be 82 MPH.

Note that for a circular hurricane, Equation 4 reduces to

[redacted]

Having determined k and α, the hurricane generated speed for the mobile home is given by

[redacted]

Thus,

[redacted] = (0, 40.99)

and [redacted] = (12.73, 12.73) + (0, 40.99) = (12.73, 53.72)

Finally, [redacted] $= (12.73)^2 + (53.72)^2 = (55.218)^2$

Thus, the total wind speed at the mobile home is 55.22 mph.

Modeling Building Types

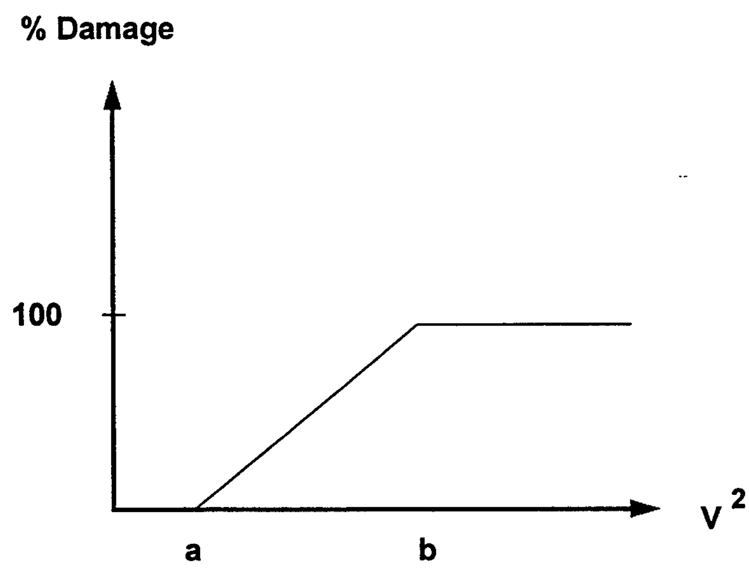
Once the wind speed is determined at any given point and time, a methodology to degrade or destroy buildings must be employed. Presently, building types are described with 10 parameters as shown below:

Bldg Type	Bldg Ht (m)	% Open	L-1	L-2	L-3	L-4	Constr Type	Total Num Rooms	Num of Floors	Bldg Class
1	5	5	10	10	20	20	1	8	1	1
2	12	5	20	20	30	30	2	40	4	2

This data structure can be used. Assume seven types of structures will be accounted for in the simulation:

Building Type	Building Height (m)	Description
1	3	mobile homes and other temporary structures
2	5	1 or 2 story residential, wood frame, older home
3	5	1 or 2 story residential, wood frame, newer home
4	5	1 story commercial
5	10	2 - 5 story commercial
6	25	5 - 10 story commercial (older construction)
7	40	5 - 10 story commercial (newer construction)

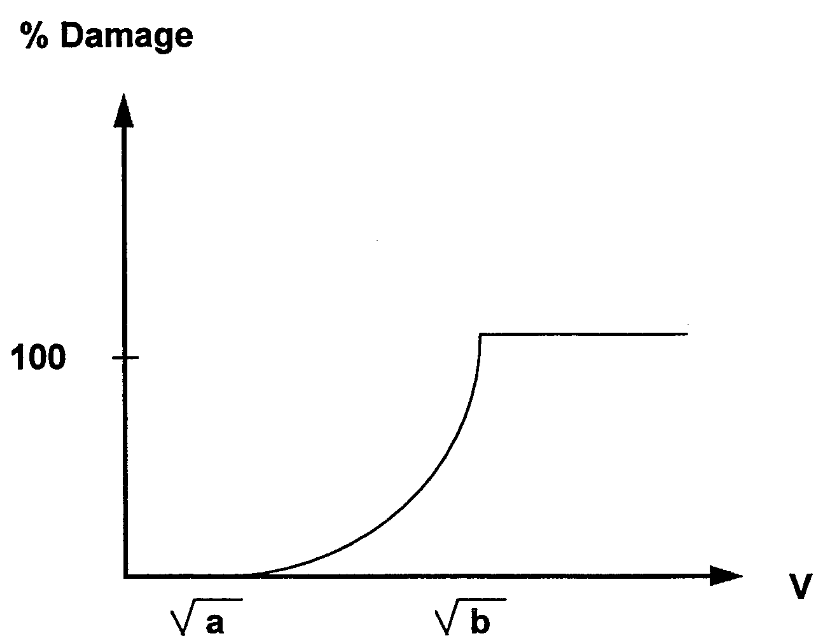
As a first step, using V^2 as input, a damage assessment function can be developed as depicted graphically below



If we let d = damage in percent, then

$$d = \frac{100}{b - a}(V^2 - a) \qquad \text{for } a \le V^2 \le b \qquad (5)$$

Note that the above curve would be shaped like a parabola as a function of V as shown below.



This seems intuitively plausible.

Thus, once the strength of the hurricane starts to decrease (for circular or elliptical contours the hurricane generated wind speed shape will always increase up to a maximum as the storm passes and then start to decrease). Thus, a percent damage can be assigned to the structure based upon the maximum wind speed. One issue is that houses and buildings behave differently depending upon the orientation of the structures with respect to maximum wind speed, surrounding terrain, quality of construction, and pure chance. To account for this randomness in the damage process, the b parameter in the damage model will be modified using a uniform random number generator.

For the seven classes of building previously presented, the following values of $\sqrt{a}$ and $\sqrt{b}$ are proposed:

Building Type	Description	[redacted]	[redacted]
1	mobile homes and other temporary structures	50	90
2	1 or 2 story residential, wood frame, older home	70	100
3	1 or 2 story residential, wood frame, newer home	60	100
4	1 story commercial	70	100
5	2 - 5 story commercial	80	120
6	5 - 10 story commercial (older construction)	80	120
7	5 - 10 story commercial (newer construction)	80	120

Note that these values were deduced from the F-scale wind speed range and respective amount of damage. This information was provided by the National Weather Service.

Example 2. Suppose for a Building Type 1 that the maximum speed encountered during a hurricane was 70 mph. Since this value is greater than the threshold value [redacted] for damage to occur, some fraction of the building will be damaged. If the strength factor B was set at its maximal value, b, then the assessed fraction of damage would be

[redacted]

However, since this is a random process (i.e., 70 mph winds affect mobile homes differently) a random number B between a and b is drawn from a uniform distribution as shown below

[redacted]

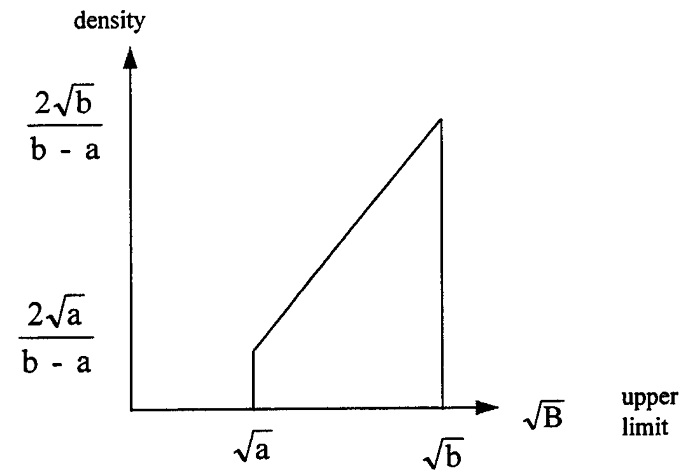
This can be accomplished by a call to the random number generator, as follows:

[redacted]

Suppose RAND returns 0.5764. This will produce an upper limit B on the V^2 for 100 percent damage for this mobile home with a value of B = 5727.84. To determine the fraction damage with wind speed of 70 MPH we use Equation 5.

[redacted]

Note in the above example that generation of the random upper limit B for V^2 from a uniform distribution over the interval (a,b) is equivalent to generating the minimum wind speed that would cause 100% damage ($\sqrt{B}$) from a triangular distribution over the interval ($\sqrt{a}$,$\sqrt{b}$):



This means that factors such as variations in building strength and shape, and aspect of building surfaces, are modeled as variations in the upper limit, $\sqrt{B}$, that would cause 100% damage. This model assumes such upper limits are more likely to be close to the maximum limit, $\sqrt{b}$, than to the lower limit $\sqrt{a}$.

Example 3. Suppose a one story residential house of older construction (Building Type 2) experiences a maximum wind speed of 105 MPH. Since this is beyond the range for the end point for the upper interval, the house is assessed a damage of 100%.

Example 4. Suppose a similar one story house sees a maximum wind speed of 80 MPH. Since the value is within the interval specify for the uniform distribution, a random number is drawn of 0.105 which produces

$$B = 4900 + 0.105(10{,}000 - 4900) = 5435.5$$

Since $V^2 = 6400$ exceeds the random upper limit of 5435.5 then the assessed damage is 100%

Default Hurricane Data

The Saffir-Simpson Hurricane Scale is used to categorize hurricanes into five classes (from U.S. Department of Commerce, 1994):

Scale Number (Category)	Sustained Winds (mph)	Damage
1	74 - 95	Minimal
2	96 - 110	Moderate
3	111 - 130	Extensive
4	131 - 155	Extreme
5	> 155	Catastrophic

Five parameters (three for the hurricane model: maximum wind speed, ground speed, median distance; and two for the eye: diameter of the eye, and percent of maximum wind speed for the eye) are required using the methodology previously presented to described a hurricane. In order simplify input, the following default values are proposed for each of 5 categories using the Saffir-Simpson Hurricane Scale:

Category	Maximum Wind Speed (mph)	Ground Speed (mph)	Median Distance (miles)	Diameter of the Eye (miles)	Percent of Max Wind Speed for Eye (%)
1	90	15	30	20	20
2	100	15	30	18	20
3	120	15	35	14	20
4	140	15	40	12	20
5	160	15	50	8	20

Note these values are meant to be representative of the characteristics of a typical hurricane for a given category. Wide variation exits for a given category can exist.

Outline For The Hurricane Model

Input Parameters

$\sqrt{a}$, $\sqrt{b}$ for a building type

maximum wind speed, W_{max}

median radius of the storm, M_r

ground wind speed, $\vec{V}_r$

storm center (Cx, Cy)

building location (x,y)

diameter of the hurricane eye = d_{eye}

percent of maximum wind speed for eye = W_f

Compute

compute $r = \sqrt{(Cx - x)^2 + (Cy - y)^2}$

if $r \leq d_{eye}$

then $\vec{V}_t = W_{max} * W_f$

else

compute $k = W_{max} - \left\|\vec{V}_r\right\|$

compute $\alpha = 2 \ln 2 / M_r^2$

compute $\left\|\vec{V}_h\right\| = ke^{-\frac{\alpha}{2}\left[(x - Cx)^2 + (y - Cy)^2\right]}$ (vector length)

compute $\vec{V}_h = c\left(x - 1, y + \frac{x - Cx}{y - Cy}\right)$ (vector direction)

where $c = \left\|\vec{V}_h\right\| / \sqrt{(x - 1)^2 + \left(y + \frac{x - Cx}{y - Cy}\right)^2}$

note that if y - Cy = 0 then

$$\left\|\vec{V}_h\right\| = [\mathrm{sign}(x - Cx)]\left(0, \left\|\vec{V}_h\right\|\right)$$

[+ produces $\left(0, +\left\|\vec{V}_h\right\|\right)$, - produces $\left(0, -\left\|\vec{V}_h\right\|\right)$]

compute $\vec{V}_t = \vec{V}_r + \vec{V}_h$

compute $V^2 = \left\|\vec{V}_t\right\|^2$

compute $a = (\sqrt{a})^2$, $b = (\sqrt{b})^2$

draw RAND

compute $B = a + RAND * (b - a)$ (Compute B only once for each structure)

compute damage:

if $V^2 < a$, $d = 0\%$

if $V^2 > B$, $d = 100\%$

if $a < V^2 < B$, $d = \dfrac{100}{B - a}(V^2 - a)$

end if

Appendix D: TERRA Training Manual

Department of Systems Engineering
United States Military Academy
West Point, New York 10996

TERRA Operator Training Course

26 - 28 July 1995

Prepared for

ORANGE COUNTY, FLORIDA

by

PAUL D. WEST

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Under the Sponsorship of the

U.S. ARMY SIMULATION, TRAINING, AND
INSTRUMENTATION COMMAND (STRICOM)
PM-FAMSIM

ORLANDO, FLORIDA 32826-3275

Course Contents

Block	Item	Tab
1	Running TERRA	A
	Setup, Routes, Preplanning, etc.	B
	Running	C
	Postprocessing	D
2	Database	E
3	Scripts	F
4	Scenario Building	G
5	Terrain Editor (TED)	H
6	Other	I

Contents

Introduction

Welcome to **TERRA**. The following lessons introduce you to the **Training Emergency Requirements for Rapid Allocation** simulation. When you have completed them, you will have the basic tools needed to plan and interactively run the emergency coordination simulation.

TERRA is an interactive, two-sided simulation. A TERRA workstation normally sees only those emergency units assigned to it, though other EOC units can be identified through a "friends" function. Looters and chemical spills appear on your screen only when they are seen.

The simulation is driven by an in-depth database of systems characteristics. Emergency Response Units are represented by icons. The people and vehicles they represent behave like the real thing -- they move at different speeds on- and off-road, carry realistic loads, and can put out fires or clear debris. These characteristics are defined in a Master Database by the system administrator, but can be modified at the scenario level by users.

Icons can be programmed as individuals or can be aggregated to represent groups, squads, or companies. However, each icon can contain only one type of system (e.g. backhoe, sheriff's car). A fire and rescue company, therefore, must have at least one icon for each system type. Systems may be mounted on other systems if it makes sense (chain saws on fire trucks).

Units move along routes you plan. Steep slopes, heavy vegetation and obstacles may slow or stop them. Routes may be added, changed, or deleted before or during the exercise. Also, keep track of how much fuel is being used. Without resupply, units will run out of these necessities.

Chapter 1

Conditions: Unusually dry winds and a lack of rain have caused an outbreak of brush fires throughout the County. Events will be displayed in the TERRA emergency management simulation.

Tasks: Set up and run a TERRA simulation, identifying key functionality.

Standards: You must respond to all calls as part of a County effort.

Set up the Scenario:

1. Log on and bring up the scenario.

   a. Enter User ID (use lower case only) supplied by your instructor.
   b. Enter Password.
   c. Enter Execute Scenario (**EE**). All future commands are upper case.
   e. Enter **001** as the scenario to execute.
   f. Enter your User Account number as the Run Number.

Important Notes

- From now on, **Return** refers to the enter (return) key on keyboard; **Enter** refers to the enter key on the numeric keypad.
- All commands (e.g. EE, FF, SS) should be typed in upper case.
- To delete the contents of a field, press the **tab** key.
- To back out of a line that is requesting input, type **XX**.
- **Select** means to place the cursor on the object, press and release a mouse button.

Question 1. What is the Terrain File Number for this scenario?

Question 2. Which Symbol File Number will be used? ________________

2. Do not change any parameters on Screen I. Press **Enter** to move to Screen II.

3. If necessary, use the arrow keys to move to the EOC field. There should be only one line, with the following information:

EOC	Side	Group	Symbol Size	Tablets
(See **Note**)	1	1	2	1

Note: This number is the workstation monitor in front of you.

4. If more than one line is displayed, use the **tab** key to delete all information except that shown above.

Question 3. Which EOC Number will be used? ______________

Question 4. What Symbol Size will be used? ______________

5. Press **Enter** to move to Screen III.

Question 5. How many obstacles and what kind will each side use?

– Blue: __________________ Red: ______________________

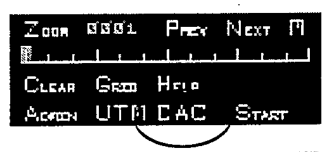
6. Press **Enter** to move to Screen IV.

Question 6. Which direction is the hurricane moving? ____________________________

7. Press **Enter** again. When an EOC icon appears on the your screen, double-click on it with the *left* button to maximize it. It will take a few minutes for the screen to build.

STOP! Your instructor will tell you when to proceed.

Display the Command and Control overlay.



1. Using the left mouse button, select **CAC** from the bottom of the user menu.

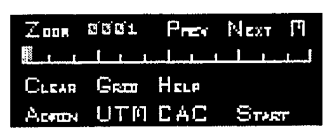
2. Select **Disp** (for Display) from the top of the CAC menu, change the CAC number to **551** by clicking the zero with the left mouse button, then select **OK**.

Question 7. What features are displayed in CAC 551? ________________________

3. Select **Add** from the top of the CAC menu, change the CAC number to 565.

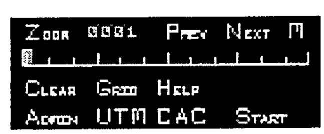
Question 8. What features are displayed in CAC 565? ________________________

4. Select **CAC** again to return to the user menu.



5. Toggle gridlines on and off by selecting **Grid** from the bottom of the user menu. Toggle the display from latitude/longitude (degrees, minutes, seconds) to Universal Transverse Mercator (UTM) by selecting the **UTM** button near the bottom of the menu.

Customize your run.

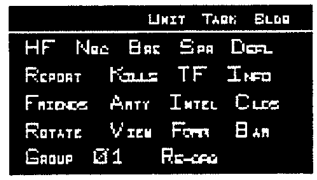


1. Zoom to your area of operations.
    a. Select the second tick mark on the **Zoom** scale at the bottom of the user menu.
    b. Place the box that in the southeast (lower right) corner of the screen.
    c. Press the left mouse button again to execute the zoom.

2. Identify terrain types.

a. Select **Info** from the TERRA menu.

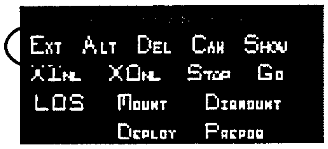
b. Click on the terrain. The location, elevation, and classification/zoning will appear at the bottom of the screen. The percentage of damage sustained by that terrain cell (100 x 100 meters) also will be displayed. If the terrain is populated, the number of people who are unaffected and who are victims also is displayed.



Question 9. — How many people are in each cell of the residential area just west of Orlando International Airport? ______________________________

3. Create a movement route.

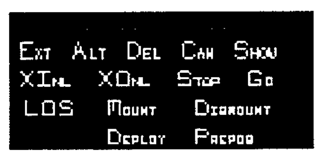
   a. Select **Ext** (for extend a route) from the Maneuver Plan section of the menu.
   b. Select one of the units on your screen.
   c. Move the cursor to the nearest road and click the *left* mouse button.



   d. Move the cursor along the road, then click the *left* mouse button again.
   e. Do this two or three more times, then identify a final destination by clicking it with the *center* mouse button.
   f. The triangles that appear are called **nodes**. These are way points. **Go** nodes (Δ) govern changes of direction. **Stop** nodes (∇) stop a unit's movement until the node is changed by the interactor. **Timed** nodes (e.g., ∇_5) are Stop nodes that automatically change to Go nodes at the game time indicated (in this case 5 minutes), *provided* that a unit is actually at that location. Nodes are toggled from Stop to Go by selecting **Alt** in the Maneuver Plan menu, then the **node** with the *right* mouse button. The easiest way to define a timed node is to plan it normally, change the timer at the top of the menu to the desired time, then select the node with a combination of <*shift*> *any* button.

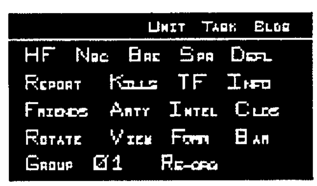
4. Alter a movement route.

   a. Select **Alt**, then the unit whose route you want to change.
   b. Select the node you want to change. An orange "rubber band" will connect the cursor to the previous node.
   c. Move the cursor to a nearby location and press the left button again.



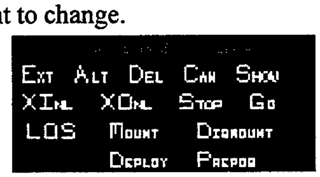
5. Redirect and resize the view fans.

   a. Selecting **View** from the Unit Status menu.
   b. Select the unit to change.
   c. Place the cursor where you want the unit to look.
      (1) Press the *center* button to change the direction.
      (2) Press the *right* button to resize the fan: pressing it when the cursor is closer to the unit decreases fan size; farther increases it.



6. Add and delete a node to an existing route.

   a. Select **Ext** (for extend), then the unit whose route you want to change.
   b. Select a node to travel <u>from</u>, then the location of the desired new node.
   c. Delete a node by selecting **Del**, then the desired node.



7. Cancel a route by selecting **Can**, the icon of the desired unit, then the icon ***again*** to actually cancel.

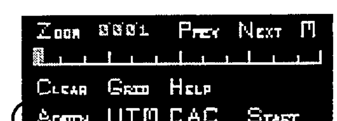
8. Plan multiple routes using a "leader."
   a. Plan a route for one of your units.
   b. Select **XInl** (for X-In Line).
   c. Select the leader you just planned.
   d. Select each unit you want to follow. Their routes will be automatically plotted to follow the leader.

9. Conduct a "terrain walk."
   a. Select **LOS** from the Maneuver Plan menu.
   b. Select the unit to conduct the terrain walk. The resulting **view fan** shows:
      (1) left and right limits of line of sight.
      (2) center sector (dashed white line).
      (3) maximum optics range (curved white line).
      (4) maximum effective range of the primary weapon (curved purple line).
      (5) clear lines of sight (orange lines). Broken lines show dead space.
   c. Select an area with the *left* button to see what that unit could see from there.
   d. Repeat Step c. to scan the terrain.
   e. Select **Clear** from the bottom of the user menu to erase the LOS display.

10. Check a unit's status.
   a. Select **Info** from the Unit Status menu.
   b. Selecting a unit with the *left* button gives basic information about the unit.
   c. Using the *center* button will display unit location and sensor height, as well as a detailed view of the icon on the world view map.
   d. The *right* button is used to show the unit's route.
   e. A combination of *shift* plus *any* button will display the ammunition status.

Question 10. What types of equipment are mounted on Engines? ________________________

Save your changes.



1. Select the word **Admin** from the bottom of the user menu with the *right* mouse button.
2. Minimize the scenario screen by selecting the smaller square in the upper right corner.
3. Ensure the cursor is in the TERRA Admin window, then enter **PS**.
4. Double-click the TERRA icon to maximize the screen.

STOP! This completes Chapter 1. Your instructor will tell you when to proceed.

Logging out. *Do so only when directed.*

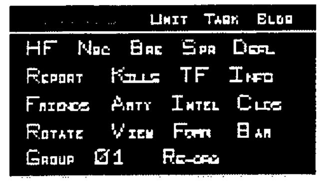
1. Select **Admin** with the *right* mouse button.
2. Minimize the screen.
3. Type **ET** in the TERRA Admin window.
4. Type **Y** to confirm that you want to end TERRA.

5. Type **XX** to end the session.
6. Select the **Exit** box at the bottom of the screen.
7. Select **OK** to quit workspace manager.

Chapter 2

Note: If you are continuing directly from Chapter 1, begin at Step 2.

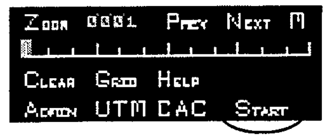
1. Log onto TERRA, bring up Scenario **001**, and **zoom** to the southeast quadrant just as you did in Chapter 1.



2. Turn on smoke effects by selecting **Clds** (clouds) from the Unit Status menu.

3. Add Command and Control overlay (CAC) 561.

Question 11. What features are displayed in CAC 561? ______________________________



4. Select the word **Start** with the *right* button.

5. Minimize the scenario screen as before.

6. Type **RR** and **return** in the TERRA Admin window; type **N** for no plan save; and press **return** for Checkpoint Frequency.

7. Maximize the scenario window. ***The exercise is now running***.

8. You may alter routes during the exercise just as you did during the planning phase.

Exercise Notes

- ✓ Fires appear in red, tornadoes in purple.
- ✓ Orange splashes indicate civil disturbances.
- ✓ White circles indicate smoke.
- ✓ Debris encounters are marked with the estimated boundaries appearing as a box.
- ✓ Gunshots are shown by an orange line connecting the firer with the victim, an asterisk indicates the receiving end.
- ✓ Disturbances not specifically identified appear as yellow squares, then a large icon of the suspected disturbance.

9. Identify the four fires that are burning.

Question 12. List the Page, UTM and Lat/Lon location and the zoning of each fire.

a. ____

b. ____

c. ____

d. ____

10. **IMPORTANT!** A tornado will appear in your quadrant during this exercise. When it does, answer questions 13 and 14.

Question 13. List the Page, UTM and Lat/Lon location and the direction of travel of the tornado.

____

Question 14. List the Page, UTM and Lat/Lon location and time when the tornado disappears.

____

11. Plan routes for Engines (only) to the fire sites. The last node must be within 200 feet of the fire.

Question 15. List the priority of response to the four fires. Why?

a. ____

b. ____

c. ____

d. ____

12. Change the run speed from 1:1 to 5:1.
    a. Click **Admin** with the *right* mouse button. Notice that the exercise is now in the **wait** mode.
    b. Minimize the screen
    c. Type (upper case) **RS** for "Run Speed."
    d. Notice the current run speed.
    e. Type **5** and <enter>.
    f. Double-click on the EOC icon to restore the screen. Notice the game clock speed.

13. Continue to fight the fires.
    a. Periodically check the status of the fire by selecting the **Info** button, then the fire.
    b. Observe the spread rate and direction of the fires.
    c. When a fire icon disappears, check the status of the terrain (step a). If the fire damage is 100 percent, it burned itself out. If it less than 100 percent, the Engine put it out.

This concludes Exercise One.

14. Log out of TERRA.
    a. Select **Admin** with the *right* mouse button.
    b. Minimize the screen.
    c. Type **ET** in the TERRA Admin window.
    d. Type **Y** to confirm that you want to end TERRA.
    e. Type **XX** to end the session.
    f. Select the **Exit** box at the bottom of the screen.
    g. Select **OK** to quit workspace manager.

15. Congratulations! In this exercise you conducted these TERRA functions:

    a. Logged onto a TERRA Workstation.
    b. Selected a Scenario to execute.
    c. Accepted parameters on Screen I.
    d. Assigned an EOC to a specific Workstation using Screen II.
    e. Accepted parameters on Screens III and IV.
    f. Displayed a Command and Control (CAC) overlay.
    g. Toggled grid lines on and off.
    h. Toggled between UTM and Lat/Lon map references.
    i. Used the Zoom control to focus on the main exercise area.
    j. Identified terrain types, damage, and population.
    k. Created, altered, and deleted movement nodes.
    l. Identified Stop, Go, and Timed movement nodes.
    m. Canceled a unit's movement route.
    n. Moved units in formation using the XInl command.
    o. Conducted a "terrain walk."
    p. Checked a unit's status.
    q. Saved your modified plan using Plan Save.
    r. Displayed smoke effects with the Clds function
    s. Minimized and maximized the game window.
    t. Ran the exercise at real time speed.
    u. Identified fires and tornadoes.
    v. Changed run speed from 1:1 to 5:1.
    w. Monitored fire status.
    x. Ended the exercise.

Chapter 3

Exercise Two

Conditions: An unpopular verdict in the trial of a famous sports figure has triggered civil unrest in the City of Orlando. The mayor has requested assistance from the Sheriff's Office to control outbreaks of looting. Events will be displayed in the TERRA emergency management simulation.

Tasks: Set up and run a TERRA simulation. Arrest looters and transfer them to holding facilities, call for assistance as required, clear debris blocking roads, respond to County EOC assignments, and log all incidents in the TERRA Command and Control Logger (TCCL).

Standards: You must respond to all calls as part of a County effort, and correctly define and forward message traffic to the County EOC.

Set up the Scenario:

1. Log on and bring up the scenario.

   a. Enter User ID (use lower case only) supplied by your instructor.
   b. Enter Password.
   c. Enter Execute Scenario (**EE**). All future commands are <u>upper case</u>.
   e. Enter **002** as the scenario to execute.
   f. Enter your User Account number as the Run Number.

2. Do not change any parameters on Screen I. Press **Enter** to move to Screen II.

3. If necessary, use the arrow keys to move to the EOC field. There should be only one line, with the following information:

EOC	Side	Group	Symbol Size	Tablets
(See **Note**)	1	3	2	1

Note: This number is the workstation monitor in front of you.

Question 16. What **Group** number will be used in this exercise? ________________________

4. If more than one line is displayed, use the **tab** key to delete all information except that shown above.

5. Press **Enter** to move to Screen III.

6. Press **Enter** to move to Screen IV. Notice there will be no hurricane in this scenario.

7. Press **Enter** again. When an EOC icon appears on the your screen, double-click on it with the *left* mouse button to maximize it. It will take a few minutes for the screen to build.

STOP! Your instructor will tell you when to proceed.

Display the Command and Control overlay.

1. Using the left mouse button, select **CAC** from the bottom of the user menu.

2. Select **Disp** (for Display) from the top of the CAC menu, change the CAC number to **565**, then select **OK**.

3. Select **Add** from the top of the CAC menu, change the CAC number to **557**.

Question 17. What features are displayed in CAC 557? ____________________________

4. **Add** CAC number **552**.

Question 18. What features are displayed in CAC 552? ____________________________

5. Select **CAC** at the bottom of the menu to return to the main menu.

6. Select **Zoom** scale 4. Position the square in the middle of the screen.

Identify your emergency response resources.

Question 19. What EOCs are represented on the screen? ___________________________

1. Select **Info** with the *left* mouse button.

2. Select a unit to identify.
   a. Select with the *left* button to identify by description only.
   b. Select with the *center* button to include a picture in the lower right corner.
   c. Select with the <*shift*> *any* button to list ammunition.
   Note: ***Arrest*** indicates how many arrests can be made by that unit.

3. Find the sheriff's car on the road in the northeast corner of Page 46.
   a. Select **Alt** from the Maneuver Plan menu, then the car.
   b. Notice that the car already has a route planned, and it will start when the Game Clock hits 3 minutes.
   c. **Do not alter this unit's route!**

Question 20. What weapons and how much ammunition is aboard sheriff's cars?

a. ____

b. ____

c. ____

Question 21. What is located in the star of each sheriff's station? ____________________

Question 22. What types and numbers of equipment is in the John Young Public Works area?

a. (Type) ______________________________ (Number) ____________________

b. (Type) ____________________ (Number) ____________________

c. (Type) ____________________ (Number) ____________________

Run the exercise.

1. Select **Start** with the *right* button.

2. Minimize the screen.

3. Follow the instructions on the screen to start the scenario.

4. Restore the screen. ***The exercise is now running.***

5. If you haven't already done so, select **Clds** to display smoke.

Identify civil disturbances.

1. Watch for orange squares flashing on your screen. This represents bricks being thrown, windows being broken, and other malicious damage occurring.

2. Watch for white circles appearing on your screen. This represents smoke from civil disturbances.

STOP! Your instructor will tell you when to proceed.

Report and log civil disturbances.

1. Hold down the **<Alt>** key on your keyboard and press and release the **<Tab>** button until the Terra Command and Control Logger window appears on your screen.

2. Click on the **Send Message** button.

3. Fill in the message header.
   a. **Required fields** are ***Priority, Location, TERRA Time, Incident.***
   b. All other fields are optional, but should be filled in as time allows.

4. Click the **Send** button.

5. **<Alt> <Tab>** back to TERRA.

Respond to civil disturbances.

1. Select **Ext** from the Maneuver Plan menu.

2. Select a sheriff's unit closest to the disturbance with the *left* button.

3. Plan a route that first goes to the nearest road, then the most direct route to the disturbance.

Report!

4. As you near the disturbance, watch for red icons representing looters.

5. Alter the destination node as necessary to bring the car up to the looter icon.

6. If the computer beeps, you have received a message from the County EOC. **<Alt> <Tab>** to the TCCL to check the message log status.

7. To respond to an EOC message, select the message, then the **View Messages** button on the TCCL Message Log. Take appropriate action and select the **Respond** button.

8. If the computer triple beeps, at least one message in your message log has gone unanswered in 15 minutes.

Arrest looters.

1. Zoom in as necessary to incident location.

2. Deputies will make arrests automatically when they are close enough.
   a. Select **View** from the menu.
   b. Select the sheriff's car.
   c. The deputy will be close enough to make an arrest when the looter is within the dashed purple line and can be seen by the deputy.
   d. Select **Info**, then the looter to determine how many are left in that icon.

3. Select **Info**, then the car with the *center* button to see how many more arrests that deputy can make before taking prisoners to a holding area.

Report!

Important Notes

- ✓ One looter icon represents 10 people. Arresting two of them leave eight. The red icon will not disappear until all 10 are arrested.
- ✓ Deputies can make only two arrests before they must take their prisoners to a holding area.
- ✓ Processing prisoners at a holding area will enable deputies to make more arrests.

Process prisoners.

1. Once a deputy has made one or two arrests, plan a route to the nearest station.

2. Select **Upload** from the Maneuver Plan menu.

3. Select the sheriff's station. The circle that appears around that station indicates an area within which you drop prisoners.

4. When the deputy's car is within the circle, select it with the cursor, which has now changed to an orange square. A message will appear at the bottom of the screen indicating that the deputy's prisoner capacity has been restored.

5. Verify that the prisoners have been transferred by selecting **Info**, then the sheriff's car with the *center* button. The arrest capability should again by two.

Report!

Detect and clear a road blocked by debris.

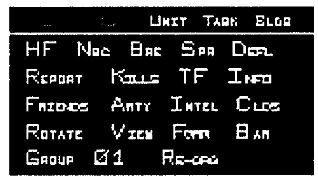
1. A unit that encounters a road blocked by debris will stop and a message will appear on the screen. This must be cleared by Public Works before traffic can again move on the road.

Report!

2. Plan a route for a Grader or Grader/Scraper from the John Young yard to the debris site. Plan the destination node in the middle of the debris area.

3. Select **TASK 4** at the top of the menu.

4. Select **Bre** (for breaching mode) from the menu. Notice that a horizontal line appears beneath the graders. This indicates that these vehicles can clear obstructions.



5. Select the grader. Notice that the horizontal line changes to a V. This indicates that the blade is down and it is ready to plow.

6. Select **Ext** and plan a route for the grader through the debris. **Double yellow lines mark the path cleared through the debris.** Vehicles using this road now must pass between these lines.

7. Select **Bre** and the grader again to "lift" the blade.

Report!

8. Return the grader to the John Young area.

9. Select **Alt**, then the sheriff's car with the *right* button to restart it.

Report!

Continue to respond to the civil disturbances.

Report!

This concludes Exercise Two.

10. Log out of TERRA.
    a. Select **Admin** with the *right* mouse button.
    b. Minimize the screen.
    c. Type **ET** in the TERRA Admin window.
    d. Type **Y** to confirm that you want to end TERRA.
    e. Type **XX** to end the session.
    f. Select the **Exit** box at the bottom of the screen.
    g. Select **OK** to quit workspace manager.

11. Congratulations! In addition to the tasks learned in Exercise one, in this exercise you conducted these TERRA functions:

a. Identified emergency response resources.
b. Identified civil disturbances.
c. Reported and logged events and responses.
d. Responded to civil disturbances.
e. Arrested looters.
f. Processed prisoners.
g. Detected and cleared a road blocked by debris.

Chapter 4

Conditions: Hurricane Rambo is crossing Central Florida from east to west. The eye is located just north of Lake Apopka. Several fires from gas line breaks have been reported and many areas are flooded. A train has been reported leaking an unknown toxic gas. Events will be displayed in the TERRA emergency management simulation.

Tasks: Set up and run a TERRA simulation, place endangered response units in protective chemical suits, contain a chemical spill, and respond to fires.

Standards: You must respond to all calls as part of a County effort and report all actions through the TERRA Command and Control Logger (TCCL).

Set up the Scenario:

1. Log on and bring up Scenario **003**.
2. Examine and accept data on Screens I - IV.

Display the Command and Control overlay.

1. Using the left mouse button, select **CAC** from the bottom of the user menu.
2. Select **Disp** (for Display) from the top of the CAC menu, change the CAC number to **565**, then select **OK**.
3. Select **Add** from the top of the CAC menu, change the CAC number to **551**, then select **OK**.

Customize your run.

1. Select **Zoom 4** and position the box just east of Lake Apopka.
2. Identify your emergency response resources.

Run the exercise.

If you haven't already done so, select **Clds** to display smoke.

Identify flooded areas.

Areas showing up in dark blue are flooded and cannot be crossed, except by boat.

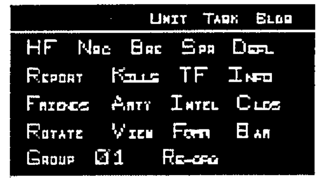
Identify a chemical spill.

1. A chemical warning will appear on your screen when someone makes a 911 call to report a chemical leak.
2. Report all incidents to the County EOC through the TCCL.

Place emergency response units in chemical suits.

1. Identify the **TASK** grouping of the unit you want to change.

a. Select the numbers at the top of the menu (1 - 5) until a corresponding number appears at the upper right of the unit.



b. Select **NBC** (Nuclear/Biological/Chemical) from the **Status** section of the menu.

c. Units with horizontal lines beneath them may don protective suits.

2. Place a single unit in protective suits.
   a. Ensure that **NBC** is highlighted and a line is below the desired unit .
   b. Select the desired unit. The horizontal line will change to a V.

3. Place an entire **TASK** grouping in protective suits.
   a. Ensure that **NBC** is highlighted and a line is below the desired unit.

   b. Select the work **TASK** on the **Status** line just above **NBC**.
   c. Select any unit in the desired grouping. The horizontal lines for all units in that grouping will change to Vs.

Contain the chemical spill.

1. Isolate the location of the spill based on reports and a vapor cloud (this may not exist).

2. Respond with appropriate resources. This must include Squad 1 (HazMat), which is located in Station 50. Squad 1 and Squad 2 are the only units that can stop the spill.

Report!

Continue to respond to emergency calls.

Report!

This concludes Exercise Three.

14. Log out of TERRA.
    a. Select **Admin** with the *right* mouse button.
    b. Minimize the screen.
    c. Type **ET** in the TERRA Admin window.
    d. Type **Y** to confirm that you want to end TERRA.
    e. Type **XX** to end the session.
    f. Select the **Exit** box at the bottom of the screen.
    g. Select **OK** to quit workspace manager.

15. Congratulations! In addition to the tasks learned in Exercises one and two, in this exercise you conducted these TERRA functions:

    a. Identified flooded areas.
    b. Identified a chemical spill.
    c. Placed emergency response units in chemical suits.
    d. Contained the chemical spill.

Chapter 5

Conditions: Hurricane Kelly is crossing Central Florida from east to west. The eye is east of Lake Jessup. Several fires from gas line breaks have been reported and many areas are flooded. A train has been reported leaking an unknown toxic gas. There also have been reports of scattered looting. Events will be displayed in the TERRA emergency management simulation.

Tasks: Set up and run a TERRA simulation, respond to all calls.

Standards: You must respond to all calls as part of a County effort and report all actions through the TERRA Command and Control Logger (TCCL).

Set up the Scenario:

1. Log on and bring up Scenario **004**.

2. Examine and accept data on Screens I - IV.

Display the Command and Control overlays.

Display Ranges and Townships, Fire and Rescue, Sheriffs Stations, and Public Works.

Run the exercise.

Good luck!

Glossary

Activity. An event that consumes time and resources and whose performance is necessary for a system to move from one event to the next.

Agency EOC. Emergency Operations Center for a particular county agency such as Sheriff's Office, Police, and Public Works.

Agency EOC Manager. Also called the Incident Commander or Agency Incident Commander.

Agency Incident Commander. The person in charge at the Agency Emergency Operations Center. These managers are the primary training audience for the Plowshares Proof of Principal Demonstration (POP-D). For the POP-D, five key agencies will be trained: The Sheriff's Office, the Divisions of Fire and Rescue, Health, Public Utilities, and Public Works. See Agency EOC Manager.

Aggregate. An activity that coalesces individual entities into a singular entity.

Air/Light Truck. Specialized vehicle which can refill air bottles on scenes and provide huge amounts of illumination for night operations.

Alarm. Event that triggers units to respond to an emergency. The number of alarms determines the magnitude of the emergency.

Ambulance. An emergency vehicle which is called to the scene of a medical emergency. Its personnel can provide medical aid of all sorts but cannot perform rescue work.

Apparatus. Any type of firefighting vehicle such as engine, truck, or rescue vehicle.

Code. Term used to indicate a person has stopped breathing.

Company. Emergency vehicle and its crew (Engine Company, Rescue Company , etc.).

Condition. The values assigned at a given instant by the variables in a system, model, or simulation.

Conditional Event. A sequentially dependent event that will occur only if some other event has already taken place.

Data. Representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or automatic means.

Database. A collection of data, organized according to a schema to serve one or more application.

Drills. An activity that tests, develops, or maintains skills in a single emergency procedure (i.e., communication drills, fire drills, and command post drills).

Echelon 1. Policy Making Group; Executive Group.

Echelon 2. Operations Group, Emergency Support Function Managers (ESFs).

Echelon 3. Agency Emergency Operations Center (EOC) Managers, also known as Agency EOC's. There are five of these per Agency. This will be the primary training audience for the Proof of Principle Demonstration.

Echelon 4. Those entities simulated by the TERRA Simulator Interactors. In this case, the simulated entities represent field operations.

Emergency Operations Center (EOC). The nerve center for emergency management. The policy board, composed of local government executives, the senior emergency management officials and the ESF representatives will be located here. In particular, this refers to the main Orange County Emergency Operations Center, location of the Plowshares Proof of Principle Demonstration (POP-D).

Emergency Plan. A description of what personnel in government should do in the event of an emergency.

Emergency Support Function (ESF). ESFs are standard support functions as defined by the Federal Emergency Management Agency (FEMA). State and local governments map their existing organizations to the FEMA ESF structure. This mapping assures consistency in defining the scope of an emergency, quantifying local abillities to respond and sizing of requests for assistance. Local governments may define ESFs in addition to those defined by FEMA to adequately meet their requierments.

EMS. Emergency Medical Service, pre-hospital care.

EMT. Emergency Medical Technician; person trained to provide basic life support in medical or trauma emergencies.

Engine. A traditional fire engine with several hundred feet of different sized hoses, a pump, ladders, generator, and various specialized rescue tools; also carries on average 750 gal. of water which can be emptied in less than a minute in a crisis.

ESF Representative. A representative of each ESF is present on the local government EOC. These representatives are communication links who pass information, request for support, etc. from their agencies to or from other agencies Big Picture".

Ethyl-Methyl Bad Stuff. A generic name for chemicals involved in a hazardous materials incident.

Event. An occurrence that causes a change of state in a simulation.

Executive Room. See Policy Room.

Exercise. One or more sessions with a common objective and accreditation.

Exercise Control Center. Location of the Host Computer. Message control is a major function performed at the Exercise Control Center.

Exercise Design Team. Group that assists the executive director in developing the exercise content and procedures.

Exercise Directive. A directive which authorizes the emergency manager to conduct the exercise.

Exercise Director. Individual who has overall responsibility for organizing the exercise; is part of the user organization.

Exercise Manager. See Exercise Director.

Executive Room. The location of Echelon 1, the Policy Making Group.

Exercise Player. See Agency Incident Commander.

Exercise Support Staff. Staff of the Exercise Director who are not Exercise Players.

Full-Scale Exercise. An activity which assists in evaluating the operational capability of emergency management systems in an interactive manner over a substantial period of time.

Functional Exercise. An activity designed to test or evaluate the capability of an individual function, or complex activity within a function.

HAZMAT. Hazardous material incident such as a gasoline spill or a radiation leak.

Host Computer. A computer that supports one or more simulation applications.

Human-Machine Simulation. A simulation carried out by both human participants and computers, typically with the human participants asked to make decisions and a computer performing processing based on those decisions.

Incident. Essentially the same as scene though normally used a little more in terms of the operations on a scene. An incident may be as simple as a rescue truck going on a difficulty breathing call or the operations starting with a hurricane evacuation. Whoever is in charge of the particular operation is the Incident Commander. See Incident Commander.

Incident Commander. Another name given to the Agency Emergency Operations Center (EOC) Manager.

Initial Conditions. The values assumed by the variables in a system, model, or simulation at the beginning of some specified duration of time.

Interactive Model. A model that requires human participation.

Janus. An interactive wargaming simulation which will provide the basis for TERRA.

Message. The actual materials that are submitted to the players in an exercise to stimulate their actions. These can be presented orally, on paper, by radio or phone, or generated by the simulation.

Narrative. Sets the scene for the simulated event and briefly describes what has happened up to the time of the exercise.

Needs Assessment. A tool for identifying the problem and then selecting an appropriate intervention. Pertains to training exercises, such as those for emergency management.

Operations Room. The location of Echelon 2, the Emergency Support Functions (ESFs).

Paramedic. Also called "Medic", this is the person responsible for patient care and can intubate and administer injections; essentially the step between basic first aid and hospital emergency room (ER) care.

Plowshares. A military sponsored project to apply military constructive simulation technology to training and analysis for emergency management..

Policy Room. The location of the Policy Making Group (Echelon 1).

POP-D. Proof of Principle Demonstration.

Rehab. Area where emergency workers go when fatigued in order to rest, take in fluids, and assure that their blood pressure has dropped adequately before resuming work.

Rescue. An ambulance with the tools aboard to perform extrication and rescue tasks, usually crewed by one Paramedic and one Emergency Medical Technician (EMT). Also called "Rescue Truck".

Scenario. An initial set of conditions and time line of significant events imposed on trainees or systems to achieve exercise objectives.

Scene. The physical site of the incident along with the victims, emergency vehicles and crews.

Sector. On large incidents, there are many components and they are called sectors. There may be several sectors relating to fire, rescue, Emergency Medical Service (EMS), logistics, public information and so on.

Sequence of Events List. A listing of all the events that are likely to occur in a particular emergency incident.

Simulation. A model that behaves or operates like a given system when provided a set of controlled inputs.

Simulator. Creates an artificial reality through the delivery of prescribed messages to players in order to evoke player response as if the exercise were an actual emergency. Simulators can be computers or people.

Simulator Interactor. The actual TERRA operator. This person will input and move resources around the TERRA terrain database at the direction of the Agency Emergency Operations Center (EOC) Manager.

Special Services Unit. A specialized vehicle and crew responsible for unusual types of fire and rescue operations, the most common being HAZMAT incidents.

Statement of Purpose. Clearly and briefly states what you plan to accomplish by conducting the exercise.

Station. Building which houses one or more companies.

Stochastic. Pertaining to a process, model, or variable whose outcome, result, or value depends on chance.

Systems Administrator. Computer specialist who starts, stops, and replays TERRA scenarios. Must have in-depth knowledge of TERRA.

Tabletop Exercise. An activity in which elected and appointed officials and key agency staff are presented with simulated emergency situations without time constraints.

TERRA. Training Emergency Requirements for Rapid Allocation; the name given to the software used by the Plowshares project.

Training Center. The location of Echelon 3, the Agency Emergency Operations Center (EOC) Managers.

Truck. Has the same crew and basic equipment as an engine, but is larger due to its extendible ladder.

Unit. Generic term for a vehicle or company.

Unix Administrator. Computer specialist who maintains and backs up system files, assures proper network connections and configuration, and deals with any computer hardware problems.

Command and Control (CAC) Overlays

Overlay Number	Description	Status
551	Firestations	Complete
552	Public Works	Complete
553	Shelters	Complete
554	Hospitals	Complete
555	Major Buildings	Complete
556		
557	Sheriff Stations and Substations	Complete
558		
559		
560	Major Roads	Complete
561	Trailer Parks	Complete
562		
563	Golf Courses and Parks	Complete
564	Bodies of Water	Complete
565	Ranges and Townships	Complete
566	Jurisdiction	Complete
567	Airports	Complete
568	Debris Clearance Routes	Complete

Terrain Feature Data

City Feature

City Type	Description
1	Trailer Park
2	Residential Area - Older
3	Residential Area - Newer
4	1 Story Commercial Area
5	2 - 5 Story Commercial Area
6	5 - 10 Story Commercial Area - Older
7	5 - 10 Story Commercial Area - Newer

Area Feature

Area Type	Description
1	Lakes
2	Paved Area
3	Park & Golf Courses

Tree Feature

Tree Type	Description
1	Undeveloped Open
2	Undeveloped Trees
3	Grass

Rivers

River Type	Description
1	Flooded Areas

TERRA Systems

Sys Num	Sys Name
1	Looter
2	Train
10	Engine
11	Truck
12	Tanker
101	DC_Car
102	ALS
103	Saw
104	BC_Car
105	Marine
106	Comms
107	Rescue
108	Air_Lt
109	Rehab
110	Woods
111	Sqd_1
112	Sqd_2
113	Dstr_T
115	Sheriff
116	Hold
117	Bus
120	Grader
121	Scraper
122	10_Wlr
123	6_Wlr
124	Backhoe
125	Chipper
126	Svc_Trk
127	16'_T
128	Crw_cab
129	Whl_Ldr
130	Pickup

Station Locations

Sheriff's Stations and Substations

Grid (UTM)	Site
800600	East Orange
505732	North Orange
705628	Orange County Communications Center
576605	Princeton Hospital
618645	Quality Inn
457593	West Orange
595529	33rd Street Operations

Public Works

Grid (UTM)	Site
504711	Apopka
909589	Bithlo
708623	Goldenrod
627564	John Young
628421	Taft
717490	Three Point
433554	West Orange
430782	Zellwood

Fire and Rescue

Grid (UTM)	Site
718629	Headquarters
414780	20
480669	28
506814	29
548572	30
502479	31
419529	34
472389	36
391592	37
554664	40
586607	41
559588	42
607540	50
605488	51
564472	52
607454	53
540418	54
601359	58
716643	63
672663	64
695593	66
645485	70
727499	71
673523	72
639442	73
784418	76
811609	80
729593	81
873581	82
795575	83
950576	84

Emergency Response Units

1	Engine	10	1	1	70	Truck	11	1	3
2	Saw	103	1	1	71	Air_Lt	108	1	3
3	Tanker	12	1	1	72	Woods	110	1	3
4	Rescue	107	1	1	73	Marine	105	1	3
5	Rescue	107	1	1	74	Engine	10	1	3
6	Marine	105	1	1	75	Saw	103	1	3
7	Woods	110	1	1	76	Rescue	107	1	3
8	Engine	10	1	1	77	Engine	10	1	3
9	ALS	102	1	1	78	Saw	103	1	3
10	Saw	103	1	1	79	Tanker	12	1	3
11	Tanker	12	1	1	80	Rescue	107	1	3
12	Engine	10	1	1	81	Woods	110	1	3
13	Rescue	107	1	1	82	Engine	10	1	3
14	Engine	10	1	1	83	Tanker	12	1	3
15	Saw	103	1	1	84	Rescue	107	1	3
16	Rescue	107	1	1	85	BC_Car	104	1	3
17	Woods	110	1	1	86	Woods	110	1	3
18	Saw	103	1	1	87	Saw	103	1	3
19	BC_Car	104	1	1	88	Engine	10	1	3
20	Engine	10	1	1	89	Engine	10	1	3
21	Saw	103	1	1	90	ALS	102	1	3
22	Truck	11	1	1	91	Woods	110	1	3
23	Saw	103	1	1	92	Saw	103	1	3
24	Rescue	107	1	1	93	Engine	10	1	3
25	Marine	105	1	1	94	Engine	10	1	4
26	Engine	10	1	1	95	Rescue	107	1	4
27	Rescue	107	1	1	96	Woods	110	1	4
148	Saw	103	1	1	97	Marine	105	1	4
28	Engine	10	1	2	98	Engine	10	1	4
29	Truck	11	1	2	99	Rescue	107	1	4
30	Saw	103	1	2	100	Woods	110	1	4
31	Rescue	107	1	2	101	Saw	103	1	4
32	Rescue	107	1	2	102	Marine	105	1	4
33	Dstr_T	113	1	2	103	Engine	10	1	4
34	Woods	110	1	2	104	Engine	10	1	4
35	DC_Car	101	1	2	105	ALS	102	1	4
36	Engine	10	1	2	106	Saw	103	1	4
37	ALS	102	1	2	107	BC_Car	104	1	4
38	Truck	11	1	2	108	Woods	110	1	4
39	Saw	103	1	2	109	Engine	10	1	4
40	BC_Car	104	1	2	110	ALS	102	1	4
41	Woods	110	1	2	111	Woods	110	1	4
42	Marine	105	1	2	112	Saw	103	1	4
43	Engine	10	1	2	113	Engine	10	1	4
44	Saw	103	1	2	114	ALS	102	1	4
45	Tanker	12	1	2	115	Tanker	12	1	4
46	Woods	110	1	2	116	Woods	110	1	4
47	Marine	105	1	2	117	Marine	105	1	4
48	Engine	10	1	2	118	Engine	10	1	4
49	Rescue	107	1	2	150	Saw	103	1	4
50	Woods	110	1	2	119	Engine	10	1	5
51	Rescue	107	1	2	120	Rescue	107	1	5
52	Engine	10	1	2	121	Sqd_1	111	1	5
53	Engine	10	1	2	122	Saw	103	1	5
54	ALS	102	1	2	123	ALS	102	1	5
55	Engine	10	1	2	124	Sqd_2	112	1	5
56	Rescue	107	1	2	125	Rehab	109	1	5
57	Engine	10	1	2	126	Engine	10	1	5
58	Saw	103	1	2	127	Truck	11	1	5
59	Engine	10	1	2	128	Saw	103	1	5
149	Saw	103	1	2	129	Rescue	107	1	5
60	Engine	10	1	3	130	BC_Car	104	1	5
61	Saw	103	1	3	131	Engine	10	1	5
62	Rescue	107	1	3	132	Engine	10	1	5
63	Rescue	107	1	3	133	Rescue	107	1	5
64	Engine	10	1	3	134	Woods	110	1	5
65	ALS	102	1	3	135	Rescue	107	1	5
66	Truck	11	1	3	136	Engine	10	1	5
67	Saw	103	1	3	137	Rescue	107	1	5
68	Marine	105	1	3	138	Woods	110	1	5
69	Engine	10	1	3	139	Saw	103	1	5

140	Engine	10	1	5	222	10_Wlr	122	1	8
141	Truck	11	1	5	223	6_Wlr	123	1	8
142	Saw	103	1	5	229	Grader	120	1	8
143	Rescue	107	1	5	230	10_Wlr	122	1	8
144	Comms	106	1	5	231	16'_T	127	1	8
145	Engine	10	1	5	232	Backho	124	1	8
146	ALS	102	1	5	233	10_Wlr	122	1	8
147	Engine	10	1	5	237	Svc_Tr	126	1	8
151	6_Wlr	123	1	6	238	10_Wlr	122	1	8
152	Scrape	121	1	6	239	6_Wlr	123	1	8
153	Pickup	130	1	6	240	16'_T	127	1	8
154	Grader	120	1	6	241	6_Wlr	123	1	8
155	Pickup	130	1	6	242	16'_T	127	1	8
156	Crw_ca	128	1	6	243	Scrape	121	1	8
157	Crw_ca	128	1	6	244	16'_T	127	1	8
158	Chippe	125	1	6	245	6_Wlr	123	1	8
159	Svc_Tr	126	1	6	246	16'_T	127	1	8
160	Grader	120	1	6	247	Whl_Ld	129	1	8
161	6_Wlr	123	1	6	249	Crw_ca	128	1	8
162	6_Wlr	123	1	6	250	6_Wlr	123	1	8
163	6_Wlr	123	1	6	251	10_Wlr	122	1	8
164	10_Wlr	122	1	6	252	6_Wlr	123	1	8
165	16'_T	127	1	6	253	Backho	124	1	8
166	Whl_Ld	129	1	6	256	Pickup	130	1	9
167	16'_T	127	1	6	257	Scrape	121	1	9
168	10_Wlr	122	1	6	258	6_Wlr	123	1	9
169	10_Wlr	122	1	6	259	10_Wlr	122	1	9
170	Svc_Tr	126	1	6	260	Grader	120	1	9
171	10_Wlr	122	1	6	261	Whl_Ld	129	1	9
172	Svc_Tr	126	1	6	262	6_Wlr	123	1	9
173	Pickup	130	1	6	263	Backho	124	1	9
174	Whl_Ld	129	1	6	264	6_Wlr	123	1	9
175	Grader	120	1	6	265	10_Wlr	122	1	9
176	Whl_Ld	129	1	6	266	10_Wlr	122	1	10
177	Pickup	130	1	6	267	10_Wlr	122	1	10
178	Grader	120	1	6	268	6_Wlr	123	1	10
179	Scrape	121	1	6	269	16'_T	127	1	10
180	10_Wlr	122	1	6	270	Whl_Ld	129	1	10
181	Pickup	130	1	6	271	10_Wlr	122	1	10
182	16'_T	127	1	6	272	10_Wlr	122	1	10
183	Backho	124	1	6	273	10_Wlr	122	1	10
184	6_Wlr	123	1	6	274	Pickup	130	1	10
185	10_Wlr	122	1	6	275	Scrape	121	1	10
186	16'_T	127	1	6	276	Grader	120	1	10
187	16'_T	127	1	6	277	Pickup	130	1	10
188	6_Wlr	123	1	6	278	Grader	120	1	10
189	6_Wlr	123	1	6	279	Pickup	130	1	10
190	16'_T	127	1	6	280	Crw_ca	128	1	10
191	6_Wlr	123	1	6	281	6_Wlr	123	1	10
192	Chippe	125	1	6	282	Backho	124	1	10
193	10_Wlr	122	1	7	283	6_Wlr	123	1	10
194	6_Wlr	123	1	7	284	6_Wlr	123	1	10
195	6_Wlr	123	1	7	285	16'_T	127	1	10
196	Grader	120	1	7	286	6_Wlr	123	1	10
197	Crw_ca	128	1	7	287	6_Wlr	123	1	10
198	Backho	124	1	7	288	Crw_ca	128	1	10
199	10_Wlr	122	1	7	289	16'_T	127	1	10
200	10_Wlr	122	1	7	290	Backho	124	1	10
201	6_Wlr	123	1	7	291	Whl_Ld	129	1	10
202	6_Wlr	123	1	7	292	Crw_ca	128	1	10
203	Scrape	121	1	7	293	Pickup	130	1	10
204	Backho	124	1	7	294	10_Wlr	122	1	10
205	6_Wlr	123	1	7	295	Scrape	121	1	10
206	Grader	120	1	7	296	6_Wlr	123	1	10
207	Svc_Tr	126	1	7	297	10_Wlr	122	1	10
208	Pickup	130	1	7	298	Backho	124	1	10
209	Pickup	130	1	7	299	Backho	124	1	10
210	16'_T	127	1	7	300	Grader	120	1	10
211	16'_T	127	1	7	301	Sherif	115	1	11
212	16'_T	127	1	7	302	Sherif	115	1	11
213	16'_T	127	1	7	303	Sherif	115	1	11
214	Whl_Ld	129	1	7	304	Sherif	115	1	11
215	16'_T	127	1	7	305	Sherif	115	1	11
216	6_Wlr	123	1	8	306	Sherif	115	1	11
219	16'_T	127	1	8	307	Sherif	115	1	11
220	16'_T	127	1	8	308	Sherif	115	1	11

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217	6_Wlr	123	1	14
218	10_Wlr	122	1	14
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224	Crw_ca	128	1	14
225	Backho	124	1	14
226	Pickup	130	1	14
227	Scrape	121	1	14
228	Grader	120	1	14
234	10_Wlr	122	1	14
235	Grader	120	1	14
236	Pickup	130	1	14
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530	Hold	116	1	15
531	Hold	116	1	15
532	Hold	116	1	15
533	Hold	116	1	15

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